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CALIFORNIA STATE
Mining Bureau.

THE

MINING INSTITUTE

OF SCOTLAND.

TRANSACTIONS,

Vol. VIII.—1886-87.

HAMILTON:
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THE MINING INSTITUTE OF SCOTLAND.

NINTH ANNUAL MEETING,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

22nd April, 1886.

JAMES S. DIXON, Esq., President, in the Chair.

About 40 members were present.

The Minutes of the last General Meeting were read by the Secretary, and confirmed.

COUNCIL'S REPORT.

The Secretary read the report of the Council as follows :—

In presenting the Eighth Annual Report, your Council have the pleasure of stating that the Institute is still in a prosperous condition.

At the commencement of the session there were 457 members

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on the roll. During the year 47 were added, 5 resigned, 14 were struck off the roll on account of non-payment of subscription, and 4 died. The net increase for the year has therefore been 24, the total number on the roll at this date being 481. Of these, 209 subscribe £1 1s. a year, and 271 subscribe 10s. 6d. a year.

The attendance at the General Meetings, both in Hamilton and Glasgow, has been fairly maintained.

Papers on the following subjects, with the discussions thereon, have been printed in the Transactions :—

The Schwartzkopff Control and Safety Apparatus for Boilers.
The Dervaux Anti-Incrustator for Boilers.
Further results of Firing Boilers with Gas from the Wilson Producer.
The Proell Automatic Expansion Gear.
Cadzow Colliery Endless Rope Haulage System.
Review of the Progressive Improvement of Mining in Scotland.
Ashworth's Safety Lamps.
Subsidence and Draw.
Mining in the Province of Huelva, Spain
Peck's Ambulance Stretcher.

The desirability of having a Glossary of Scotch Mining Terms was brought under the notice of the Institute. A Glossary has been compiled by the Secretary and submitted to the members for revisal, and is in course of completion.

The Summer Meeting was held in Kilmarnock, and included a visit to the Engineering and other Public Works of the town. It was well attended and was highly successful.

The Mining Exhibition held in Glasgow in September last, was the outcome of a resolution passed at last Annual Meeting. A report of the Exhibition has been sent to all the members, and it is unnecessary to enter into detail regarding it in this report. It may be sufficient to mention that the Exhibition embraced examples of Machinery and Appliances in connection with all departments of Mining, laid out on 213 separate stands, for which exhibitors paid £763 15s. 6d. The Exhibition was open 23 days, and was visited by 36,780 persons, of whom 8182 were colliery workmen. After all expenses were paid, there remained a balance of 42 per cent. of the sum paid by the exhibitors, and that proportion was repaid to them in terms of the regulations.

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Additions have been made during the year to the list of kindred societies, with which an exchange of Transactions is made. The Institute now receives by exchange the valuable reports published by the Director of the Geological Survey of the United States.

Large additions have also been made to the Library during the year by purchase and donation. It may be stated that the purchases include a considerable number of the geological maps of the Coal Districts of Scotland, viz. :—the whole of the maps that are published on a scale of one inch to the mile, and the maps on a scale of six inches to the mile of the whole of Lanarkshire and some of other mining centres.

It is gratifying to refer to the following large list of donations received during the year :—

From JAMES SMART : A Clanny Lamp.
From RICHARD THOMSON : A Bainbridge Lamp.
From Dr WM. WALLACE, Glasgow : Analyses of Scotch Ironstones, &c.—3 copies.
From Manchester Steam Users' Association : Their Monthly Report.
From JOHN M'NEIL, State Inspector of Mines, Colorado : First Report of State Inspector of Mines for Colorado.
From JAMES GILCHRIST : A Ballardie Safety Lamp.
From JAMES S. DIXON : Vols. XI. to XVI., and XXI. to XXVIII. of Engineering ; Two Guineas for library purposes.
From ROBERT MAUCHLINE, Shenandoah, Pa. : 18 Plans and Sections of the Geological Survey of Pennsylvania ; Second Report of Progress, Anthracite Coal Region—Part 1.
From the SECRETARY OF STATE : The Mines Inspectors' Reports for 1884, and Mineral Statistics for 1884—two copies of each.
From WM. TOPLEY, 28 Jermyn Street, London : Pamphlet on the National Geological Surveys of Europe.
From JAMES M'CREATH : One Guinea for library purposes.
A Practical Treatise on Mine Engineering, by G. C. Greenwell—1855.
A Practical Treatise on Pit Machinery, by Wm. Moore—1859.
Transactions of South Wales Institute of Engineers—Vols. I. and II.
Transactions of the Midland Institute of Mining Engineers—61 parts of Vols. I. to X.
Transactions of North Staffordshire Institute of Mining Engineers —26 parts of Vols. I. to VIII.
A Practical Treatise on Mining, Land, and Railway Surveying, by H. D. Hoskold—1863.

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The PRESIDENT said, though this statement showed that they had a smaller balance than at the end of last year, they had, he thought, spent their income on very good objects.

ELECTION OF OFFICE-BEARERS.

The CHAIRMAN announced that the gentlemen nominated at the last general meeting were now duly elected. Their names are :—

President :

JAMES S. DIXON, 170 Hope Street, Glasgow.

Vice-Presidents :

JOSEPH T. ROBSON, Jesmond Villa, Cambuslang.
JAMES SMART, Balgreen, Hamilton.
DAVID ANDERSON, Bothwell Road, Hamilton.
JOHN M. RONALDSON, Belton Villa, Pollokshields.

Councillors :

THOMAS ARNOTT, Summerlee Iron Works, Coatbridge.
ROBERT BEITH, Townlands Colliery, Hamilton.
ARCHIBALD BLYTH, Bent Colliery, Hamilton.
DAVID COWAN, Carron Iron Works, Falkirk.
ROBERT L. GALLOWAY, 98 West George Street, Glasgow.
JAMES GEMMELL, Govan Colliery, Glasgow.
JAMES GILCHRIST, Earnock Colliery, Hamilton.
JAMES HASTIE, Greenfield Colliery, Hamilton.
JOHN HOGG, North Motherwell Colliery, Motherwell.
JOHN LOVE, Gartness Colliery, Airdrie.
JAMES PRENTICE, Stanrigg Collieries, Airdrie.
HENRY TELFER, Overtown Colliery, Wishaw.

The President then delivered the following address :—

PRESIDENT'S ADDRESS.

GENTLEMEN,—On taking the chair at another Annual Meeting of our Institute, I have to thank you for the honour of being re-elected to the office of President.

We have every reason to congratulate ourselves on the continued prosperity and usefulness of the Institute, and of its very flourishing condition both as regards membership and finances.

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I think it is instructive to look back on the past as recorded in the published Transactions and see what subjects connected with our business of mining in its various ramifications have been touched upon. I find that we have had papers on very many subjects, which may be classed as follows, viz. :—On working and modes of working, 15; lamps and lighting, 14; boilers, steam raising and appliances, 9; haulage, 6; pumping, 5; winding and appliances connected therewith, 4; accidents, explosions, and inspection, 4; geological, 4; blasting explosives, 4; ventilation and fans, 3; cages and appliances, 3; signalling, 3; coal-cutting machinery, 2; gas detecting apparatus, 2; mine driving, 1; screening, 1; surveying, 1; sinking, 1; and general, 16. We have here a list of close upon a hundred papers, on upwards of thirty subjects, widely different, but all throwing floods of light on the matters treated. The titles of these papers shew how diverse are the subjects that are embraced under Mining Engineering, which comprehends within itself the knowledge of the civil and mechanical, and now of the electrical engineer; besides that of the practical geologist, and the special information as regards the details of mining itself, which is only derived from long experience and coming constantly into contact with the exceptional circumstances which are continually arising in carrying forward the works of a colliery or other mine.

Those having charge of mines have a variety of difficulties to encounter, which are not exceeded in engineering as carried out above ground. From the moment the surface of the ground is broken difficulties begin, often in the shape of running sand and mud, then water, sinking through whin and other hard rocks, and when these are overcome and the desired workable seams of coal are reached, a fresh one appears in the shape of the insidious gas. Then there come the difficulties met with in working the coal seam itself in the shape of dykes and slips, which require to be proved and cut by stone mines.

An important subject is the best system of working steep seams, say from 1 in 3 to perpendicular. In the matter of haulage, on the inclination of the seams in conjunction with the levels, such seams require special treatment; and how to do this to best advantage is a wide

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separated from the stones by taking advantage of their different specific gravities, and this is worked out either by pulsating machines or by gravitating machines, the latter having an ascending flow of water under a sufficient head to float the coal, but to allow the heavier particles to sink. This looks correct in theory, if it can be borne out in practice, which I understand is the case, and is at present being applied in this district. On such a wide subject we have only had one paper, but I trust it may be more fully gone into in future.

A matter of great interest to the mining world has been brought to the front during the past year. I refer to the water cartridge, in which an inner cartridge of blasting gelatine is enclosed in an outer casing filled with water, which on the ignition of the charge by electricity extinguishes the flame. If all that has been said of it is correct, and the matter of cost can be met, blasting in the most fiery mines can be carried on with safety. This is a matter that might be inquired into by the Institute, as it is one of universal interest in view of the probability of legislation of a stringent nature being passed in regard to shot-firing in the ordinary way; and without blasting it is impossible to work many mines to profit.

An important event of the year is the completion and issue last month of the report of the Royal Commission on Accidents in Mines. This report, which I have no doubt will be carefully studied by us all, is the result of seven years' labour and inquiry into all the various phases under which accidents occur in mines. The work of the Commission comprised minute and searching experiments into many subjects which required elucidation. These experiments appear to have been carried out in a most elaborate manner, and have enabled the Commissioners to draw certain conclusions and make certain recommendations. I do not intend to examine these or pronounce on them in any way, but these are matters that might with perfect propriety be taken up and discussed by Mining Institutes with great profit to all concerned. The desire of the Commissioners, and our desire, is to do all that is practically possible to prevent or lessen accidents, and if their labours have this result they will have been well spent.

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As regards our Institute, the past year has been a conspicuous one in its annals as that on which the Exhibition of Mining Plant and Appliances was held under its auspices. This exhibition was most successful and instructive in every respect, and was the first of its kind. It is now about to be followed by one under the auspices of the North of England Mining Institute, and we cannot wish it better than that it may be as successful as our own.

The past year has been another of depression in mining in all its branches as carried on in this country. From the returns it will be seen that the output of coal, which is a safe gauge of what is transpiring in all industries, has decreased by nearly $1\frac{1}{2}$ millions of tons. From our past experience, a decline in the output of coal for two successive years, and to the extent of nearly $4\frac{1}{2}$ million tons, is unprecedented, and shews a severe retrograde movement; more especially as in its past history the coal output shews a continuous and steady increase, with comparatively few and insignificant relapses. Had general trade expanded as we had become accustomed to expect, the coal output last year should have been about twenty millions of tons more than it was, which would have meant good trade and plenty to do for all concerned. Let us hope that the turn of the tide is near, and, with a return of more general activity, that the business of mining may get its share of the increased prosperity, so as to give a fair return to the large amount of brain and hand power and capital that are devoted to its development.

Mr JAMES SMART had much pleasure in proposing a vote of thanks to the President for the interesting address he had favoured them with. He had given them a very concise account of their work as an Institute since they started, and had thrown out some very useful hints for their future procedure, which he hoped would be taken advantage of by the members. (Applause.)

The PRESIDENT, in response, said he was deeply thankful for their appreciation of his efforts. (Applause.)

The following were elected by ballot as ordinary members :—

J. B. SNEDDON, Addiewell Works, West Calder.
ALFRED G. PATTERSON, Earl of Rosslyn's Collieries, Dysart.
WILLIAM DUFF, 79 Finnieston Street Glasgow.

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In the author's absence, the following paper on "Burnett's Roller Mining Wedge and Drilling Machines" was read by Mr W. J. Bird :—

ON BURNETT'S PATENT ROLLER MINING WEDGE AND DRILLING MACHINES:

WITH AN ASSOCIATED SYSTEM OF COAL GETTING.

As many of you will be aware, the leading subject of this paper formed one of the many exhibits of the recent Mining Exhibition held in the Burnbank Hall, Glasgow, in connection with this Institute, where it received considerable notice and generally favourable criticism; and, had it not been for this circumstance, it is more than probable that I would not have had this opportunity of submitting the results of the several trials that have been conducted, and to which I shall shortly invite your kind attention.

It is claimed for the Roller Wedge that it is at once a safe, efficient, expeditious, and economical substitute for the blasting agents now in use.

As its name implies, the apparatus is so designed that the surfaces of the wedge, instead of being in sliding contact with the feathers or checks, are mounted in purely rolling contact; and, as the rollers are arranged on each side of the wedge, it will be understood that the latter in advancing travels twice the distance covered by the rollers on the stationary cheeks or feathers, the centres of the rollers having a velocity ratio only half that of the advancing wedge. The power is hence doubled, which, added to the enormous reduction of friction consequent on the use of the rollers, constitutes the principal feature of the invention. The model submitted for inspection clearly illustrates the action of the wedge.

Another important feature of the apparatus is the compound

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ratchet lever. In the drawing of the wedge (Plate I.), and which represents the apparatus as specially designed for coal, the ratio of the leverage is approximately as 4 : 1 ; but it will be understood that this proportion may be varied to any desired limit. The pitch of the screw is $\frac{3}{8}$in., so that when the compound lever is applied this may be represented as being $\frac{3}{32}$in. pitch ; and I would here point out the great advantage of this arrangement as found in actual practice.

With the supplementary ratchet lever applied to the nut of the screw direct, the wedge after being inserted into the hole is quickly tightened hard up to position. It is now applied to the compound lever, and this is worked until the "jud" gives freely, when, on becoming easy to work, the supplementary lever is again returned to the nut, and the wedge is rapidly followed up until the jud is brought down. After the jud has fallen, the wedge is soon re-adjusted for the next operation. It will hence be obvious that, whilst it is easily possible to make wedges without this attachment, its use is a decided advantage, both in point of durability and in the economy of time in working the wedge.

Even with the present pitch of screw it will sometimes be found that the coal or stone may be brought down by the ordinary ratchet lever on the first motion. The compound lever is, however, at all times available in cases where increased power may be required, the total effect of which, after making a reasonable allowance for friction, is represented by a bursting pressure of five tons per pound force applied to the end of a two-foot lever. The apparatus is hence easily capable of being worked by one man.

The wedge is self-contained, compact, strong, and not liable to derangement.

It is difficult to compare the comparative efficiency of gunpowder and wedges in detaching coal. Amongst others, the wedge has this advantage, that its power is exerted in a line at right angles with the plane of the wedge, while the blasting force of powder is radiated away all round the circumference of the shot hole, and is thus scattered.

The blasting force of powder is estimated by good authorities at 20 tons per square inch. Assuming the case of a shot-hole 1$\frac{1}{2}$

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inches diameter and a cartridge 9 inches long, the force is exerted on a surface of 40 square inches. Certainly the effective power is exerted on not more than $\frac{1}{3}$ of the circumference, say a surface of 13 inches. This makes a total effective force of 260 tons.

It is often supposed that an efficient mechanical wedge will become necessary to obviate the dangers incident to the practice of shot-firing. Without at all depreciating the value of this consideration, it should be borne in mind that there is a great commercial advantage secured by wedging instead of blasting coal, owing to the increased proportion of round coal obtained.

This is due to the fact that powder exerts a shattering influence on the coal and makes a large proportion of small, and even the round coal that is got is liable to disintegration during screening, loading, and transit. The Roller Wedge, on the other hand, exerts a steady and continuously-increasing pressure until the coal gives way.

These wedges are now made of $4\frac{1}{4}$ inches and $3\frac{3}{4}$ inches diameter for coal and stone respectively. A wedge of $3\frac{1}{2}$ inches diameter has been tried for coal, but it was found that under heavy pressure the feathers were buried into the coal without any effective result being obtained.

Referring to the diagram of the wedge, the following is a description:—A is the wedge-bar formed at or in continuation of the screw. This screw and wedge-bar conveniently made with a plain or parallel part A^1, between the wedge A and the screw A^2, is enclosed between two bars or feathers, B B^1, which are placed in the bore-hole as shown, and which, instead of being plain according to my first patent, are made of a channel section, as shown in Fig. 2, that is to say, with a ledge or rib on each side, which enclose the wedge-bar, and thus, while affording greatly increased strength, serve also to keep the rollers, C, in their place sideways, and thus dispensing with the frame in which the rollers are mounted; and instead of the feathers being rivetted into the shoulder, D, I prefer either to dovetail the feathers as shown or provide them with T heads fitting into corresponding recesses in the flange or shoulder. These bars or feathers are formed with a taper corresponding with that of the wedge, and the bottom bar, B_x, which has to bear the greatest strain, is made stronger than

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the top bar, B, as shown; and the rollers, C, are placed in the intervals between the inner taper wedge-bar, A, and the two outer taper bars, B B^1. A nut, E, placed on the screw and abutting against a suitably recessed face in the shoulder gives facility for pulling the inner wedge-bar, A, out towards the face of the coal, whereby the rollers, C, while ascending on the inclines of the inner taper-bar, A, and the inclines of the outer taper-bars, B and B^1, will force the two latter apart to the required expansion. The nut, E, is formed with a flange which is held in place by means of a bearing plate, E_x, having lugs therefor as shown. On the nut, E, at its outer end is formed a square, E^2, for a ratchet lever to fix on. The ratchet lever, K, is shown on the drawing, and may be about two feet long, and is preferably constructed as shown. The nut, E, is provided with a pawl-wheel, E^3, the pawl, F, for which is fitted in a fork, G, swivelling on the plain parts of the nut, E, like a ratchet brace, and the fork, G, is provided with a cam-like slot, G^1, for a bush or boss, forming a lever, H, to work in, which boss is fitted with a square, H^4. This boss or lever H, is mounted freely on a pin, D^1, fixed to an arm or bracket, D^2, extending from the shoulder, D, and has a segmented edge incision which fits the circumference of a smaller roller, H^3, also mounted freely on a pin which is fixed in the fork end, H^1 H^2, of the lever, H. This roller, H^3, works in the cam slot in the fork, G.

The application and action of the apparatus is as follows:— The necessary "holing" having been made and the hole drilled, the wedge is inserted as shown. The ratchet handle or supplementary lever, K, is then affixed to the square, E^2, formed on the extended portion of the nut, E, which latter is thereby rotated, and the nut, E, bearing against the shoulder, D, will begin to draw the wedge, A.

The operator will continue this, I may say, direct action of the handle until more power is required than can be thus directly obtained. He then shifts the handle or supplementary lever on to the square, H^4, of the lever, H, and by imparting successive oscillations to the same, the roller H^3, acting against the cam slot G^1, of the fork, G, will cause the pawl, F, to pass a tooth at each oscillation caused by the crank or lever, H, and thus power

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in direct proportion to the ratio of leverage between the lever, H, and lever, G, will be obtained, thereby causing the final bursting of the coal or stone, as has already been explained.

Before applying the ratchet handle, K, to the lever H, it will be necessary to secure the ratchet wheel, and this is effected by locking the pawl with the pin as shown, or a separate lever may be employed.

A plan (shewn at the meeting, but not printed herewith) represents the wedge as per my first patent, dated January, 1884, No. 1351, to which I have referred, and is submitted for reference and comparison with the improved patent as now described.

In the original patent the bars or feathers were of plain section, the rollers being kept in position by a cage or frame.

In the improved patented design this frame is dispensed with, and bars or feathers of channel section introduced, which, whilst affording greatly increased strength, serve also to keep the rollers, C, in position.

The compound lever has also been greatly improved both in design and general efficiency, the ratio of leverage in the present arrangement being nearly uniform.

Another form of roller-wedge is shown, Plate II., the rollers arranged in zig-zag fashion, and abutting on two thrust rollers—one at each end of the wedge proper; but even in this arrangement it will be easily understood that a considerable amount of friction must exist, whilst the wedge has only half the travel and hence less than half the power of those of the standard type.

I have also claimed and described, in mining wedges, various forms of the combination with a wedge-shaped bar and parallel feathers, or with wedge-shaped feathers and parallel jamming bars, or with taper wedging bar, of anti-friction rollers or balls, so arranged and operating by the rollers ascending as to produce the necessary expansion, and whilst I prefer to make drawing in contra-distinction to forcing wedges, I also claim and show modifications of the latter.

It frequently happens that more than one inventor may be experimenting in the same direction, and although the results

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obtained may be entirely different, yet the original idea with each may be the same, and this is precisely the case with the roller wedge.

A patented wedge of the ordinary type, that is to say, with the surfaces in frictional contact, had been tried at South Hetton Colliery with a fair amount of success, but the enormous power required to work it, and its great liability to break down, led Mr J. Dunn, the engineer of the company referred to, to direct his attention to the subject with the result that he produced and actually tested a wedge, of which Plan No. 7 (shewn at the meeting), is a correct description. This was tried in a seam in which the "kirving" is made at the top. It however, failed to lift the coal, some of the rollers having split and the screw become deranged, and no practical results were attained. Another wedge-bar was made, having one roller arranged in conjunction with a sliding piece. This, however, was not tried, and thus the matter ended. There can be no doubt that had the first wedge been constructed with two inclined planes instead of one, thus equalising the travel of the rollers, and had the rollers been constructed in solid form instead of being perforated, a better result would have followed.

In wedges of this construction, even granted that they can be satisfactorily made, the advantage to be gained is only to be found in the reduced friction of the rollers against the abutting surfaces on the wedge-bar, or against the pins on which they may be arranged to rotate, as against the friction of the whole surfaces of the wedge-bar on the feathers of those of the ordinary type; whilst, as already pointed out in the case of my roller mining wedges, there is purely rolling contact with the enormous advantages of double travel of the wedge-bar, and hence double power consequent on the particular method of application of the rollers.

This experiment was made in the latter part of December, 1883, while the date of my patent is January 12th, 1884, and I hardly need state that the subject was under consideration by me for some considerable time prior to that date.

The following are a few experiments selected with the view of illustrating the gradual perfection and development of this machine, and its application:—

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The first list of trials were made in the Low Main seam at Wingate Grange Colliery, Durham, diagrams of which are given. The coal is household, and is very hard.

Experiment I.—In a 4 yards bord of 3ft. 3in. section a "jud" was "kirved" and nicked on both sides to the depth of 3ft. The wedge hole was drilled in the middle of the jud at the top. After twelve minutes' wedging, the entire jud was brought down.

Experiment II.—A bord 5 yards wide, 3ft. 4in. thickness of seam, was "kirved" across 3ft 3in. in and 1ft. 5in. deep at the front, and "nicked" on both sides 3ft. in, tapering from 1ft. 4in. to 7in. Wedge hole drilled in middle of jud. In fourteen minutes the whole of the jud was detached in two large pieces. In this case only 8in. of the available 18in. travel of the wedge was utilised.

The great ease with which these trials were effected induced the writer to test the machine under more severe conditions, and accordingly a wall 4 yards 1 foot wide was selected. This jud was "kirved" only, not "nicked," but quite fast at both ends. When the hole had been drilled to a depth of 2ft. 6in. the drilling apparatus broke down. The wedge was, however, inserted as far as the depth of the hole would allow, and after working the wedge for twenty-five minutes the jud was brought down, with the exception of two pieces in each "nook," and which were in a loosened condition.

At this time I had not a drilling machine of my own, and the machine referred to was much too light for the size of drill.

Experiment III.—This, a somewhat severe test, was made in a bord 4½ yards wide by 3ft. 6in. thick. The jud was fast at both ends. Depth of "kirving," 3ft. 3in. A wedge hole was drilled 3ft. from each side at the top, and two wedges inserted, and in fifteen minutes the whole of the coal was detached to within 18in. at top, as shown; so that practically the whole of the jud was brought down, and this in splendid condition.

The next trial may be taken as of an exceptionally severe character, and was made simply with the object of testing the full capacity of the wedges.

Experiment IV.—In a 5 yard bord two holes were drilled 1ft.

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from each nook. A wedge was inserted in each fast end, and after twenty minutes' working of the wedges the coal came down right across the place to the full depth of the wedge hole.

The three following trials were with the stone wedge, in the Harvey seam :—

Experiment V.—In a bottom "canch" of grey metal, 9ft. wide by 2ft. thick, a hole was drilled in the middle. The whole of the canch was detached in ten minutes, the stone being easily removed by levers.

Experiment VI.—Top canch of grey metal, 8ft. across by 1ft. 4in. thick. In this instance a diagonal face was exposed. The hole was drilled near the left nook, and the stone brought down right across in twelve minutes.

Experiment VII.—Top canch of "post girdles" in gateway at a trouble. Width of place, 6ft. ; thickness of canch, 10in. The stone soon gave, and when partly detached rested on the pack walls until finally liberated—the time occupied in detaching the stone being about fifteen minutes.

It is claimed for the Roller Wedge that it will exert an effective force four times as great as can be obtained by the use of wedges in sliding contact. Experiments were made at Tursdale Colliery at the suggestion of Mr A. L. Steavenson, and in response to a wish expressed by him at the discussion on Mr Bird's paper before the North of England Institute of Mining and Mechanical Engineers.

These trials were made in the Busty seam, which is 4ft. 8in. average thickness. It is coking coal, almost destitute of "cleat," and considered difficult to detach. The Compressed Lime Cartridge and the Hydraulic Wedge have both been tried in this seam, and both have failed. The Roller Wedge was tried in comparison with another patented wedge working in sliding contact, and considered to be about the best of its kind. One roller wedge only was used for each jud, while two sliding wedges were allowed for the same. All the places tried were kirved and sheared on one side. As only one Roller Wedge was employed, it was necessary to obtain good results that it should be inserted not more than 3ft. from the fast nook.

The Roller Wedge brought down the coal—the times occupied

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in wedging being 13 minutes, 11 minutes, 17 minutes, and 8 minutes respectively. The sliding wedges brought their juds down in 28 minutes, 22 minutes, and 2 hours and 5 minutes respectively. In this last case the two sliding wedges failed to detach the coal, and a third wedge had to be inserted before the jud was brought down. It was evident, and admitted, that none of the juds could be brought down with one sliding wedge, while one roller wedge brought them down in (on an average) one-fourth of the time that two sliding wedges accomplished it.

In the various experiments referred to, the results were obtained with considerable ease, and with the object of securing a wider application for the wedge, experiments have been made in blocking out the coal from the solid seam, and these also have so far been highly successful, and it is the opinion of the writer that a great number of seams may be worked on this system, which I now beg to submit for your kind consideration.

Plate III. represents the proposed method.

The present practice, as is well known, generally consists in having the face of the coal in a line with the "cleat," or natural cleavage of the coal (the exceptions being in headways working in the bord and pillar method, and in driving headways and making pillars for the commencement of long-wall working), and to cut away or "kirve" in the coal along the face, either a parallel grove or inclined incision at the top, but more generally at the bottom of the seam, either by means of suitably constructed machines, operating cutting tools, or by hand with the pick, and then to lift up or break down the coal, either by the use of a chemically-prepared blasting agent, or by mechanical means, such for instance, as a wedge or wedges.

Now, one part of the proposed system relates to the use of a powerfully constructed and smoothly working wedging appliance (such, for instance, as my roller wedge) for the purpose of detaching the coal endwise. Holes are drilled for the reception of the wedge, at say right angles, or with any desired degree of inclination, with the face of the coal, at suitable intervals, into which the wedge or wedges is or are inserted and operated in such a manner as will presently be described. The practice of

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"kirving" or under-cutting the coal is thus dispensed with, it only being necessary to have what is known as a "loose" or open end at which to commence operations.

Whilst my wedge will detach the coal at any angle with the "cleat" or parting, it will be noted that the conditions of "kirving" and "blocking" off the coal are entirely different. In the former case the best results are obtained by working in a line with the "cleat" or parting, and this brings me to the next and very important part of the proposed system, according to which, instead of making the face of the coal in a line with the "cleat" or parting, it is proposed to make the same at right angles therewith, and by this means secure the advantage of the "cleat" or parting for the wedge in blocking-out the coal.

By this system of wedging a considerably increased percentage of large coal may be obtained, at, in many, if not all instances, a reduced cost of labour in production, whilst it is at the same time a safe method of working. It is specially applicable to the system known as long-wall.

According to a modified method, I may work end on with the present system, but in this case the operations of drilling and wedging would have to be performed separately. This latter method would, however, be specially applicable in the case of driving headways, as in the long-wall method, or in working the wall in the bord-and-pillar method.

For the more convenient and expeditious carrying out of the system, I propose to employ a specially constructed tram or bogey, mounted on a suitable wheel base, and provided with two revolving cradles, one at either end of the tram or bogey. On one cradle is placed the roller wedge, mounted on wheels or rollers, or arranged in suitably constructed guides, so that it may be easily placed in position for wedging by moving it forward into the hole drilled for its reception, and after the coal has been detached, the wedge will be held in position, and may then be withdrawn and re-adjusted for the next operation of wedging. On the other cradle, at the other end of the tram or bogey, I may conveniently attach an apparatus for drilling the wedge holes. When the drilling machine is made with a screw-feed bar, I prefer to make the feed variable, or adjustible, to suit the different

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degrees of hardness of the coal, and to meet the varying conditions of the drill, whether blunt or sharp. For this purpose I make the feed nut conical on the outside. Resting on the top of the said conical nut is a keep or block, which is acted upon by a screw provided with a hand-wheel, and operating against the said block through the intervention of a spring, or springs. When the regulating screw is slackened back, the conical nut resting against its shoulder will freely rotate with the screw on which the drill is mounted, and will thus put little if any pressure on the drill; but on adjusting the regulating screw the said keep or friction-block will allow the conical nut to rotate only at the desired rate, or may entirely secure it, and thus give the desired amount of feed up to the pitch of the screw; or, in other words, the nut may have any amount of slip, or no slip. The feed nut, instead of being conical may be cylindrical, and instead of one friction block there may be two, and the nut may be provided with conical roller bearings, which latter are a special feature in my machines.

I prefer to use a drill of half the length of the depth of the hole required, and when this is bored, to reverse the machine, and having withdrawn the drill, to run the machine along the cradle towards the face of the coal, and so return the drill, and perforate to the required depth.

The friction feed affords the advantage that after the hole is drilled, on reversing the machine, there being no resistance to the drill on its return, the full pitch of the screw is given, and hence it is quickly returned.

These machines—wedge and drilling apparatus—may be worked either by hand or any suitable mechanical means, such, for instance, as by a rope passing over suitable pulleys; or they may be provided each with a suitable motor, and driven by air, water, or other motive fluid direct, the latter being conveyed to the apparatus by means of a pipe or other suitable connections.

There may be more than one of each mounted on the tram or bogey, and one or more of both kinds may be worked either separately or together; but, in order to carry out the work expeditiously, it is proposed to drill one or more holes first, and then

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to drill and wedge simultaneously afterwards until the last hole of any particular place or face is reached, when, of course, only the wedge or wedges will be used.

The relative positions of the holes may be considerably varied to suit the peculiar circumstances of each case, and in seams of considerable height it will only be necessary to block off or out the coal for a certain height, and then to wedge down the super-incumbent mass in the ordinary way.

In the process of blocking out the coal, it is simply detached or loosened with the wedge, and is finally liberated by means of suitable levers.

Plates IV. and V. show an arrangement of power machines as described.

It is also proposed to use shallow tubs or hutches in such seams wherever practicable, in which at present it is the rule to make height for the ordinary tubs by blasting or wedging down the top or taking up the bottom stone respectively as the face of the coal is advanced, and by the use of such shallow tubs or hutches dispense with the blasting or wedging the said stone, which would greatly increase the economy of working and, as pointed out, dispense with stone work to a very large extent, as it would then only be necessary in the waggon way, &c.

In Plate III., representing the proposed method of working, you will please note that the waggon way is to be carried up to the face, and to intersect the latter at any desired number of points as may be proved to be most convenient for working.

A suitable siding is in each case proposed to be made at the end of each working place for the accommodation of a convenient number or set of tubs, into which the contents of the said shallow tubs are discharged, and from whence the ordinary tubs when filled are conveyed to the pit-shaft and sent to bank.

For the greater convenience of working the system, I propose to use narrow gauge portable tramways, in which are arranged any convenient number of crossings, as shown, so that the shallow tubs, as soon as filled at whatever point, may readily be placed on the outer line of rails and conveyed to the "tip" at the siding, and may on returning empty be easily placed where desired for again filling.

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In working the machine with compressed air, better ventilation is secured in the working places. The motors, as compared with the engines used in ordinary mechanical coal cutters, are very small.

Further experiments are being made, and the writer hopes by the time this paper comes on for discussion to be able to submit some further practical results of an interesting nature.

I have already referred to drilling machine, as per Plate IV., with variable screw feed. Plate VI. represents a hand drilling machine of the same type. With this apparatus holes may be drilled at any desired angle. The power is applied by two crank handles through a train of wheels so arranged as to provide a slow forward feed motion and quick return, provision being made for fixing the crank handles to the spindle of the large intermediate wheel, as well as that of the driving pinion.

A novel type of drilling machine is shown in Plate VII., one of which is now in course of construction, and of which the following is a description :—

The drilling machine proper is in the form of a "cylinder," mounted in suitable adjustable or fixed bearings, and provided with conical thrust rollers on a strong iron frame. The cylinder bearing may be secured to the frame as in the drawing, in which the apparatus is shown as specially designed for drilling top and bottom holes ; or it may have facilities for being fixed in any desired position.

In this apparatus the ordinary screw feed bar is thus supplanted by the aforesaid cylinder, wherein works by fluid pressure a piston terminating in a rod, which at its outer end carries the socket into which the drill is fixed. Around the said rod is fixed a tube which, however, is clear of the inside of the cylinder, and which, by a clamp or chuck, can be connected or disconnected from the inner or piston rod.

The tube is prevented from turning in the cylinder by having one or more flat sides or a groove, the cylinder end being formed to suit. The drill is thus rotated with the cylinder by any suitable mechanism, such, for instance, as tooth wheels or ratchet levers, and at the same time, fluid, which is contained in a reservoir, as shown, is

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forced into the cylinder through a swivel connection by means of a force pump, and the drill is pushed hard against the material to be drilled. The same crank-shaft which drives the pump may also work the aforesaid tooth-wheel gear. Or when the cylinder is turned by ratchet gear, the pump may be worked from the cylinder.

By varying the amount of fluid forced into the cylinder the speed of the feed is regulated.

In drilling deep holes, and for the purpose of rendering the apparatus more portable, more than one tube may be arranged outside the drill or piston rod, and when more than one is used, each succeeding outer tube is, of course, of larger diameter so as to act telescopically. It is thus possible to use a much shorter cylinder than would otherwise be necessary. In order to withdraw the drill, a valve, which I designate the feed and return valve, and which communicates with the reservoir, is opened, and also the small air-valve, as shown when the fluid flows back, and the drill can be brought out, bringing with it nearly all the dust and drillings.

The *modus operandi* may briefly be stated as follows :—

We will suppose the machine to be fixed in position, and everything in order for the commencement of operations. Now, by turning the handles, *d. d.*, rotary motion will be imparted through the train of wheels, *b. b. b.*, to cylinder, *c. c.*, and tube, *d. d.*, and through clamp nut, *e.*, to rod, *f.*, and hence to drill, *g.*, which may also be secured with a clamp nut, as shown and marked, *h.* ; *i.* is the piston, and which latter is free to rotate with the cylinder, *c. c.* Attached to the spindle of the handles, *d. d.*, is the eccentric, *j.*, working in the sleeve or slot, *k. k.*, of the pump ram, k^1 to which a reciprocating motion is thus imparted ; *l. l.* are the suction and delivery valves respectively ; *m.*, the air-valve, and *n.*, the feed and return valve. It will be understood that as the drill is being rotated in the manner described fluid will be forced by the ram, k^1 through the delivery valve and connections to the piston, *i.*, and the quantity of oil or other fluid so forced, and hence the feed, may be regulated by the valve, *n.*, which, when opened, will allow any desired quantity of fluid to be returned to the reservoir. The feed or

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travel of the piston is hence susceptible of the finest adjustment. On the completion of the stroke, the valve, *n.*, is fully opened, and consequent on the withdrawal of the drill from the hole, the rod, tube, and piston are severally forced back to their original position as shown, and the oil returned to the reservoir. Now, release the clamp nut, *f.*, and withdraw the rod, *e.*, and so advance the drill to end of hole, and again tighten the clamp nut, *f.*, when, on the readjustment of the valve, *n.*, the handles are again worked until the hole is completed, when the drill is again withdrawn in the manner as already described, and the operation is completed.

Experiments will shortly be made with different forms of drills, full particulars of which will be submitted at an early date.

It is very important that the wedge holes be bored with precision, and that the outside of the wedges be turned to suit, so as to nicely fit the hole; and it is with this object in view that the drilling machines referred to have been perfected.

DISCUSSION.

Mr ROBERT STEWART inquired as to the cost.

Mr BIRD thought the cost of the wedge was £17, but he spoke under correction on the point.

Mr R. L. GALLOWAY—Without the drilling machine?

Mr BIRD—The wedge alone.

The SECRETARY said it might be of interest to the members to know that the Council had appointed a committee to examine the experiments about to be made at Greenfield. Through the kindness of Mr Hastie, some of the members would be invited; and the committee would report the result of the experiments to next meeting, when the discussion would come up.

Mr BIRD said perhaps the subject was best suited for an adjourned discussion, and after hearing the results of the actual experiments in their own neighbourhood they would be better able than now to form an opinion on the machine. Mr Burnett, he believed, would then be in attendance, and he had no doubt they would have a very interesting discussion.

The PRESIDENT said it was their usual practice not to discuss

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a paper at any length on the night upon which it was read. He quite agreed that this was a paper that required to be studied, and the light thrown on it by the experiments would facilitate this very much.

Mr JOHN HOGG, as to the use of the wedge, asked if it had ever been tried to force the coal out of the solid, as described in the latter part of the paper, viz., by getting behind the coal in the long-wall working and forcing it out.

Mr BIRD said this had not actually been tried in long-wall workings, but in stoop-and-room—which was certainly quite as difficult—it had, and the coal had been forced out into the loose end.

Mr HOGG asked if the coal had been brought out whole, or by forcing a gutter in the centre of the coal, and was it brought out from roof to pavement?

Mr BIRD—Certainly. The seam was 3ft. 2in. or 3ft. 3in., and the coal was brought out from top to bottom, the full expanse of the wedge.

Mr HOGG asked if this method would be tried at Greenfield.

Mr BIRD said that remained to be seen. It depended upon how the coal at Greenfield treated it. They would be better able to inform them about that next week, perhaps.

Mr HOGG said he thought the point was very important, and this was the reason why he brought it up. He had seen a similar process tried, but never successfully, and it would be interesting to know if this wedge could force the coal out. He suggested that a trial of this kind should be made at Greenfield or elsewhere.

Mr BIRD said Mr Burnett had made arrangements to meet this wish.

Mr DAVID JOHNSTON said it would depend a great deal on the nature of the parting and on the pavement. If they had a very strong adhesive coal they would never break it out in the solid piece.

Mr JAMES HASTIE asked if Mr Hogg proposed to block it out without holing.

Mr HOGG—Yes; that is what the paper describes.

The PRESIDENT—Do you state the amount of expansion when the wedge is full in?

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Mr BIRD—The total expansion of these wedges that are here is 2in.—1in. on the wedge below and 1 divided between the two feathers. Stone wedges were made ¾ of an inch, and others 1½, which had suited coal where the parting was good, but not otherwise. The usual expansion was 2in.

Mr HASTIE remarked if the machine was working in a seam with 6 or 8 feet of surface on the top, it might block out the coal as Mr Hogg stated.

Mr HOGG—I did not say so; the paper did.

Mr BIRD—I must accept the responsibility of the statement. The wedge certainly had done it, and there was more than 600 feet of surface. The seam had good partings at top and bottom, which was in its favour.

The discussion was adjourned.

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To

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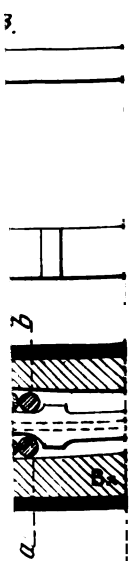
WITH A.



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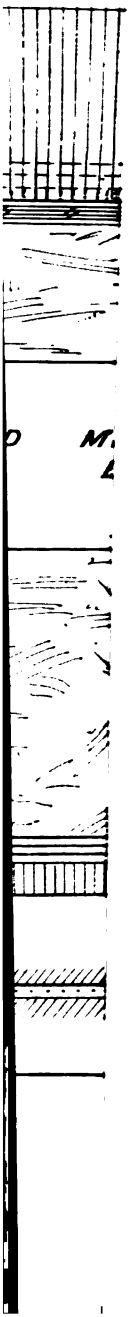

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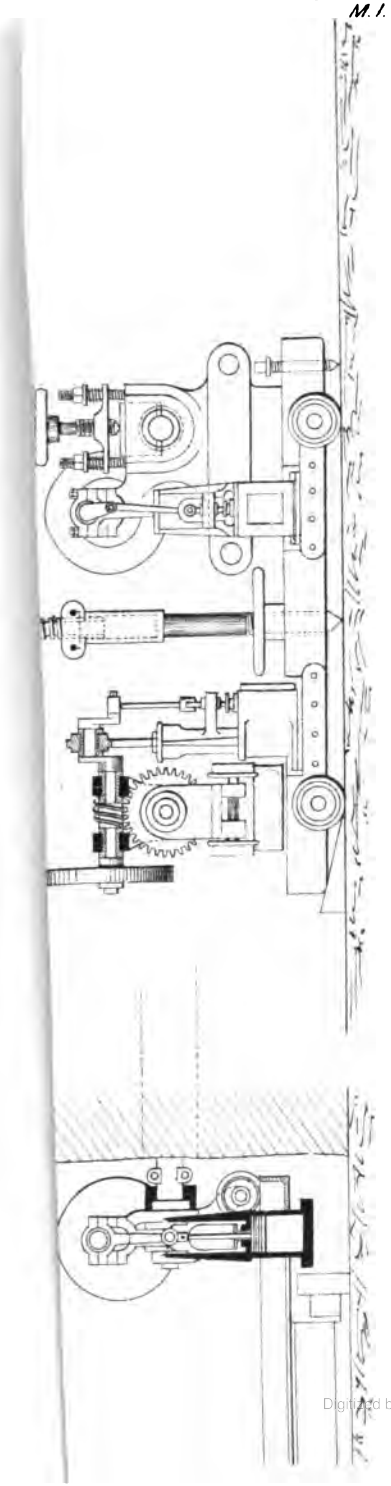

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THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,

27th May, 1886.

JAMES S. DIXON, Esq., President, in the Chair.

About 35 Members were present.

The Minutes of the Ninth Annual Meeting were read by the Secretary and Confirmed.

The following were elected by ballot as Ordinary Members :—

JOHN ELDER ROME, Shotts Iron Works, Shotts.
CHARLES RUSSELL, Harthill Colliery, Whitburn.
DANIEL M'KENZIE, Blackhill Colliery, Bishopbriggs.
JOHN M'KENZIE, Lambhill Cottage, Bishopbriggs.
JOHN NIVISON, Dykehead Colliery, Larkhall.
GEORGE FRED. BELL, 2 Belmont Crescent, Glasgow.
JAMES MURRAY, Carnock, Cambuslang.
JOHN M'KNIGHT, Langdales Colliery, Greengairs.

Mr ALEXANDER M. GRANT, Engineer, Kilmarnock, was nominated for election at next General Meeting as a Councillor in room of Mr Blyth, who has been appointed Treasurer.

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BURNETT'S PATENT ROLLER MINING WEDGE AND DRILLING MACHINE.

The PRESIDENT said that owing to the drawings in connection with the paper describing this machine not having been got ready in time, and the paper being to a great extent descriptive of these drawings, they were scarcely in a position to enter upon its discussion. He, therefore, proposed that the discussion be adjourned, which was agreed to.

Mr BEITH then read the following paper on a hydraulic apparatus for bringing down coal :—

ON AN EXPERIMENT TO BRING DOWN COAL BY HYDRAULIC MEANS.

By ROBERT BEITH.

SEEING that the discussion of Mr Burnett's paper is adjourned until next meeting, I will draw your attention to another apparatus which was applied for the same purpose and tried at the Backmuir Colliery of the Clyde Coal Coy., Hamilton, fully three years ago. This apparatus is called the hydraulic test; but before laying our experiments before you, permit me to refresh your memories regarding the discussion which took place at the General Meeting, 11th January, 1883. The discussion referred to was on Mr Gilchrist's paper on "Blasting by Lime" at Earnock Colliery. During the discussion, the ex-President, Mr Moore (see page 285, Vol. IV.), said he "had always an idea if they introduced "water, say at 2000 lbs. on the square inch, into the hole and made it "tight by means of India-rubber, they would by that pressure bring "down the coal just as effectively as by lime, or powder, or any "other means. Suppose two pistons, the diameter of the hole, were "connected by a pipe two feet long with a hole in it; by introduc- "ing this into a three inch hole and pumping water in between the

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"two pistons, the requisite amount of pressure could be got, while "the one piston would balance the other, and there would be no "tendency to be blown out however much pressure was applied."

After this discussion, Mr Hamilton, secretary of the Clyde Coal Coy., and I had a conversation relative to the bringing down of the coal in the stooping at Backmuir Colliery, which resulted in this trial being made. At that time Mr D. Johnston, hydraulic engineer, Glasgow, was consulted, and arrangements were made to apply the hydraulic pressure as described by Mr Moore to the forcing down of the coal. The place selected for the trial was a part of the workings where stooping operations had been going on for some years, and where a lift, fifteen feet wide, was being taken from the side of a stoop. The place was holed four and a half feet in for fifteen feet along the side of the stoop, after which three holes were drilled. The first hole was put in six feet from the corner of the stoop, it was three inches in diameter and four feet deep; the second hole was four feet from the first, and the third was also four feet from the second—the holes being placed much in the same position as when powder was used, that is to say, about the same distance from the roof.

The arrangements being completed, the experiments were proceeded with in presence of Messrs Hamilton, Fairweather, Johnston, and myself. The results of the first day's experiments were comparatively *nil.* The pump used had a ram, one and a half inches in diameter, with a lever several feet in length, which was not sufficient to give the pressure required. Consequently, the experiments had to be abandoned for that day and another pump got.

The pump secured for the second day's experiment was of the following dimensions, viz.:—The ram was five-eighths of an inch diameter, with a leverage on the handle of four to one. With this pump a good pressure was got; and on the thrusts of the pump, we can safely say, there was a pressure of 1000 lbs. on the square inch. When the pressure was at its best, the coal cracked and made a great noise as if coming down, and from the noise it made we thought the experiments were going to be successful, but, unfortunately the water commenced to ooze through invisible seams, coming out of the coal like a dew, and forming little

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streamlets while the men kept pumping. At the time when the coal cracked and sounded as if it were giving way, the pressure was at its best, and it must only have been the expanding of very small passages, as in no place did the escaping water come away with a spout, but formed like a dew over various parts of the coal, and which combining formed a tiny streamlet. When we saw this we did not prosecute the experiments any further.

DISCUSSION.

Mr RALPH MOORE said he did not think, if he had had the making of this apparatus, he could have more completely carried out his own idea, and he was glad to hear that the results were so promising. The failure had evidently been that, on the first rending of the coal, so much water escaped as to prevent the necessary pressure from asserting itself, proving if such a thing was to be useful it must be some other than a hand pump,—something able to keep up the pressure. Notwithstanding the partial leakages that the experimenters found, still the test was hopeful, he thought, so far as it had gone, and he did not think the thing could have got a fairer trial.

Mr DAVID JOHNSTON explained that he made the apparatus from a sketch given him by Mr Moore, and the result of the trial was as Mr Beith had stated. He next proceeded to construct another machine which would keep up the pressure continuously, and which, he was perfectly sure, would bring down the coal; but he found that a Charles Thomas Chubb had, sixteen years ago, patented a machine almost identically the same, and on finding that out they gave the experiments up.

Mr MOORE pointed out that the previous patent was now out.

Mr R. L. GALLOWAY asked if Chubb's apparatus had been tried.

Mr JOHNSTON replied in the affirmative, and said it had proved a failure. It was, however, the case that it had been tried in the solid, whereas he would have used it at the stoops. Seeing what had taken place, he (Mr Johnston) did not think it worth while to go to any further expense.

Mr HASTIE asked if Mr Johnston had a gauge on?

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Mr JOHNSTON replied in the negative. The small pump had only a §in. ram, whereas it would have needed a larger ram and engine power to do it: manual labour could not. He would have tried the use of powder to keep up the power, but shortly thereafter the water cartridge was brought under the notice of the public in a lecture by Professor Abel, which stopped him from experimenting in the matter.

The PRESIDENT said he remembered some years ago, when the North of England Mining Institute was in Glasgow, that there was a paper read on hydraulic wedging, though he did not remember the name of the author.

Mr JOHNSTON said it was mentioned in the Government Report as one of the methods of bringing down the coal.

Mr MOORE said it was very evident that they must have a great excess of power,—something that manual labour would not do. They must have some machinery,—an air engine or something of that kind. Of course, if they applied manual labour, he did not know that it could be better applied than to a hand wedge or some other wedge; but, unless they could employ something else than hand labour, he did not think it would be of much use. It was a very expensive power manual labour, but, if they could have a small engine or an air pump, it might be practicable.

The PRESIDENT said they were much obliged to Mr Beith for bringing his tests before them. His paper was a record of an unsuccessful experiment, but perhaps it might lead to something, and cause others, if they tried such a thing, to go on another course, which might be successful. He did not remember the history of Chubb's Patent, but probably the elements of success were in it if properly tried.

Mr RONALDSON asked if any of the members had tried a Belgian system in which a feather wedge was used in stonework, and was driven in with drilling machinery. It was a percussive drilling machine, only it was replaced with a hammer head, and it seemed to be successful on the Continent where tried.

Mr JOHNSTONE—Is it wrought with compressed air?

Mr RONALDSON—Yes.

The PRESIDENT—It is a wedge driven in with an air engine instead of a man's hammer.

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Mr RALPH MOORE then read the following paper :—

NOTES ON AMERICAN MINING MACHINERY.

BY RALPH MOORE.

ON a former occasion I gave a description and sketches of some of the machinery in use in the mines in America. I have recently had some sketches sent me by the Risdon Iron Company, San Francisco, of machinery used in the silver mining of the Western States of America, and I venture to submit them to the Institute. Very likely of themselves they may not be applicable to our mines here—although, perhaps, some of them may—but, in any event, they may be new to most of the members, and their publication cannot fail to help those who may be in want, at some time or other, of kindred appliances.

ORE AND WATER BUCKETS.

The drawings on Plate VIII. represent Ore and Water Buckets. They are made of the best boiler plates, and are barrel-shaped. I also give the current prices of these articles.

This is the best form of bucket for use in shafts or winzes where there are no guides, its shape preventing it from catching on projecting timbers or rocks. The Ore Bucket has a swinging bale to admit of the bucket turning when being dumped, which is done by attaching a hook, suspended on a hanging rope, to the eye in the bottom of the bucket, and lowering with the hoister. The Water Bucket does not turn over, but for emptying, it is lowered until its valve is opened by the spindle resting on the bottom of the water box. It opens automatically when filling, and automatically closes when the bucket begins to rise.

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TABLE OF STANDARD SIZES, WEIGHTS, AND PRICES.

ORE BUCKETS.				WATER BUCKETS.			
Diameter.	Height.	Weight.	Price.	Diameter.	Height.	Weight.	Price.
18 in.	26 in.	175 lbs.	$40	20 in.	30 in.	200 lbs.	$45
20 ,,	30 ,,	200 ,,	45	22 ,,	32 ,,	230 ,,	50
24 ,,	30 ,,	245 ,,	54	24 ,,	34 ,,	260 ,,	57
26 ,,	32 ,,	270 ,,	60	26 ,,	36 ,,	300 ,,	66
28 ,,	36 ,,	300 ,,	66	28 ,,	38 ,,	370 ,,	80
30 ,,	40 ,,	400 ,,	88	30 ,,	42 ,,	425 ,,	100
—	—	—	—	30 ,,	52 ,,	500 ,,	115

OVAL BAILING TANK.

On Plate IX. is shewn an Oval Bailing Tank. They are made of various sizes, and well braced inside. They are for work in vertical shafts, and are arranged with shoes for wooden shaft guides. This style of tank is also arranged for rope guides. These tanks are fitted with Safety Catches when required.

Lesser Diam.	Greater Diam.	Height.	Capacity.	WEIGHTS.		PRICES.	
Inches.	Inches.	Inches.	Gallons.	Plain.	With Safeties.	Plain.	With Safeties.
30	40	60	245	875	1,075	$125	$250
32	42	72	330	1,050	1,250	150	275
36	48	84	490	1,400	1,650	200	350
42	48	96	650	1,750	2,000	250	400
42	54	96	700	1,950	2,250	275	475

CYLINDRICAL BAILING TANK.

The drawings on Plate X. represent a Cylindrical Bailing Tank. They are made of various sizes, and well braced inside. They are for work in vertical shafts, and are arranged with shoes for wooden shaft guides. This style of tank is also arranged for rope guides.

DIAMETER.	HEIGHT.	CAPACITY – GALLONS.	WEIGHT.	PRICE.
30	60	180	775	$100
30	66	198	820	115
30	72	216	865	120
36	60	265	1,350	190
36	66	290	1,400	200
36	72	315	1,460	210
36	78	340	1,530	220

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RECTANGULAR BAILING TANK.

On Plate XI. is represented a Rectangular Bailing Tank, as arranged for self-emptying. This tank discharges itself on arriving at the station without reversing the engine, and does not require a man to let the water out. It has an extra valve in the bottom to enable it to fill more readily. These tanks are made for wooden shaft guides. The shoes above the tank are extended and safety catches put on when desired.

Width.	Length.	Height.	Capacity.	Weights.			Prices.		
				Plain.	With Sinking Guides.	With Safetys.	Plain.	With Sinking Guides.	With Safetys.
Inches.	Inches.	Inches.	Galls.	Pounds.	Pounds.	Pounds.			
32	42	72	420	1,400	1,725	1,725	$225	$260	$375
36	48	84	620	1,800	2,150	2,150	275	325	450
42	48	96	820	2,400	2,800	2,800	375	425	650
42	54	96	940	3,000	3,400	3,400	450	525	725
42	60	108	1180	4,000	5,000	4,500	600	675	900

ORE AND WATER SKIP.

A Self-Emptying Ore and Water Skip for inclined shafts is shewn on Plate XII. The bale is attached to a pivot behind the centre of gravity, so that it will tip when it is run over the dumping track. The dumping is accomplished by making the rear wheels with a projecting face of smaller diameter, which catches on the dumping track and elevates the back end, and the skip is thus tipped to a proper angle for dumping. When lowering, the rear wheels must necessarily pass down first, returning the skip to its proper position.

Capacity. Cubic Feet.	Weight. Pounds.	Price.
10	500	$75
15	700	100
20	900	130

SELF-DUMPING GIRAFFE.

Plate XIII. shews a Self-Dumping Giraffe on the same principle.

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SELF-DUMPING SKEETS.

These (shewn on Plate XIV.) are designed for use in vertical shafts for hoisting ore and water. For sinking purposes they are far superior to any other appliance now in use, as they are easy to shovel into, and are equally as well adapted to bailing as to hoisting dirt or ore. In most cases, pumping from the bottom of a shaft while sinking may be dispensed with where the Skeet is in use, as the water and dirt can be put into the Skeet at the same time. They are made of the best material, with safety catches, so that in case of accident to the rope they will catch on the guides, thus obviating all danger to the workman at the bottom. The drawings plainly illustrate the manner of dumping.

The Skeets are made with steel or iron boxes. The frames can be single or double bar frames, made of Norway iron. The double bar frames are the stronger, and facilitate taking off or putting on guides. They are stiffer, and are best adapted to Skeets of over two and one half tons capacity.

Contents. Cubic Feet.	Weight. Pounds.	Price.
20	1,700	$700
30	2,000	800
40	2,400	900
50	2,600	1,000
60	2,800	1,100
70	3,000	1,200

PITCHFORD & WALKER'S IMPROVED SELF-DUMPING SKEET.

The improvements obviate the necessity of the movable switch, and simplify the dumping arrangements. (See Plate XV.)

Skeets are in use at the following mines :—Chollar, Norcross, Savage Shaft, Virginia City; Yellow Jacket Mine, Foreman Shaft, Overman Mine, Union Consolidated Mine, Ward Mine, all on the Comstock Lode; Eureka Consolidated Mine, Eureka, Nevada; Oro and Noonday Mine, Bodie; Plymouth Consolidated Mine, Amador County, California; New Almaden Quicksilver Mines, California; Scotia Mine, Grass Valley, California, and many for sinking winzes in different mines.

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LIGHT SAFETY CAGE.

Plate XVI. represents a light, Single-Decked Safety Cage, for work in winzes and prospecting shafts, where constant and heavy work is not required. They are made of angle iron and sheet iron, well riveted together and braced. The roof is made to open to the centre, like our other cages, and the safeties are first-class in every particular. These cages are arranged for sinking when required, by putting on the long guides.

SINGLE-DECKED SAFETY CAGE—TABLE OF WEIGHTS AND PRICES.

PLAIN.		WITH SINKING GUIDES.	
Weight.	Price.	Weight.	Price.
800 lbs.	$240	1000 lbs.	$300
900 ,,	275	1150 ,,	350
1000 ,,	300	1250 ,,	375

DISCUSSION.

The PRESIDENT said they were all very much obliged to Mr Moore for bringing this description of American Mining Machinery before them; and when they had time to look into the drawings and study the different appliances, they would no doubt have something to say, and elicit some information which would be useful, either by adopting the machinery or by getting hints from them which they could apply otherwise. He asked them to accord a hearty vote of thanks to Mr Moore. (Applause).

Mr MOORE, in response, threw out the suggestion that members would be conferring a benefit on the Institute were they to bring under its notice any novelties in machinery or mechanical contrivances which they might possess. Many people had such and thought everybody knew of them, whereas they did not know them. For instance, here was Mr Beith, who had made a very important experiment which they would never have known anything about except for this new wedge coming up; and there might be many things that individual members thought trifling, but which were not so. The importance of this he illustrated by

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reference to the arrangement for the lengthening of the spigot of the working barrel of pit pumps, which had been in use by some for forty years, but which was not generally known. In fact, he continued, some men who had been accustomed to work among pumps—men of strong minds—had many remarkable devices for saving labour and time which were not generally known.

The PRESIDENT said he thought they would all agree with Mr Moore that there were many things in use that, when they saw them, they wondered they had never thought of them before; and it would be well if they had as many as possible brought before them.

The SECRETARY read the following notes on the Telemeter System, which had been brought under his notice by Mr F. J. Rowan :—

THE TELEMETER SYSTEM.

THE Telemeter is the result of a commercial and economic necessity. By means of the Telemeter system an indication of the temperature of a thermometer, the pressure of a steam-gauge or barometer, the height of water in reservoirs, ponds, rivers, tanks, etc., or the height of a gasometer can be transmitted electrically from the primary instrument, the Transmitter, to a Receiver, which may be located at any distance from the Transmitter. The Receiver not only constantly indicates each change in the primary instrument, but also keeps a record, in red ink, of every change which has been registered in the Transmitter, which latter may be miles distant. The Receiver also has an alarm bell, which rings whenever the index hand moves above or below the maximum or minimum point at which the alarm hands have been set.

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THE TELETHERMOMETER.

The Telethermometer consists of two instruments — the Transmitter and the Receiver. The Transmitter contains a finely adjusted Thermometer, with a round dial, upon which an index hand accurately registers the temperature where the Transmitter is located. The Transmitter has an electrical device for transmitting to the Receiver an indication of each change in the temperature. The two instruments may be miles apart, and yet whatever the temperature is at the point where the Transmitter is located will be accurately indicated by the index hand on the dial of the Receiver. The Receiver may be with or without a recording dial. If the recording dial is used, each change in the temperature will be recorded in red ink, and a continuous record of it kept, showing what the temperature has been for each week in the year.

The Receiver may, or may not, have an alarm bell which rings whenever the temperature rises above, or falls below the maximum or minimum point at which the alarm hands have been set. If a careless employé should allow the temperature to fall below or rise above the predetermined limits ordered by the management, the alarm hands would continue to indicate the number of degrees the temperature had exceeded the limits prescribed.

By locating the Receivers and Recorders in the office, the management has at all times a complete knowledge and control of the temperatures throughout an entire establishment.

Price, from 110 dols. to 150 dols.

THE TELEMANOMETER.

For the convenience and practical information of steam users this instrument is of the greatest value. Not only may the steam pressure at one mill or factory be indicated and recorded at a point, distant or otherwise, but the pressure at any number of mills or factories may all be indicated and recorded at the same point, thus enabling a superintendent, having charge of several establishments, to be positively informed what steam is being carried at each place. The records made by this instrument are

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indelible and may be preserved for years, showing the pounds of steam at each minute of the day or night, and form a valuable reference.

The alarm hands may be set at a minimum or maximum pressure, either of which, when obtained, causes the alarm bell to ring automatically, calling attention to the fact. Price, 85 dols. to 100 dols.

TELE-HYDROBAROMETER.

The Transmitter is the instrument located where the heights of the water are to be measured. The Receiver is located in the office, and indicates and records the heights of the water as measured by the Transmitter.

The transmitting mechanism is enclosed in a japanned iron case, with polished brass ring, dial ten inches in diameter, and is perfectly protected from dust and moisture. On the back of the case is a grooved brass pulley, which is revolved in one direction by a wire attached to a float, and in the opposite direction by means of a counter-shaft and weight. The pulley communicates its motion to the mechanism within the case for transmitting the height of the water to the Receiver. The whole is rigidly supported by a japanned iron frame, and is further protected by a glass case.

The indicating dial, for the fractional divisions, is nine and one-half inches, and the secondary dial, for the even feet, two and three-quarter inches in diameter. In the Receiver, the secondary dial carries the alarm hands for ringing a bell when the height of the water reaches any desired limit. The recording dial is fourteen inches in diameter and the record made is distinct and indelible. Both instruments are thoroughly made of the best material and finished in a superior manner. The Transmitter and Receiver, which may be located any distance apart, are connected electrically, and are operated by a battery of Prism Leclanché cells, placed in the office. This battery, in use in all telephone lines, requires no attention.

Two classes of instruments are made, indicating heights in feet and inches, or in feet and decimals of a foot. Price, 325 dols. to 350 dols.

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THE TELEBAROMETER.

The Telebarometer is practically a syphon Barometer which transmits to some distant point, electrically, a constant indication of the atmospheric pressure. The Receiver constantly indicates the pressure registered by the primary instrument (Barometer). If with a Recording Dial, a continuous record is kept of what the pressure has been. The Alarm hands and bell operate in the same manner as specified in the descriptions of the Telethermometer, Tele-hydrobarometer and Telemanometer.

The Telebarometers would prove of value in registering the pressure in mines and for meteorological stations and Government observatories.

The Barometer can be constructed to register at any interval desired. Price, 175 dols. to 200 dols.

DISCUSSION.

The PRESIDENT said he did not know whether they could make much use of any of those Telemeter instruments, but apparently they might sit in the office and know what was going on in all the different departments. He had often seen floats arranged to show the height of water in lodgments. A thing of this kind might be useful in that way and in many ways. He thought they were obliged to Mr Rowan and Mr Barrowman for bringing the subject before them.

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Moore's Notes on
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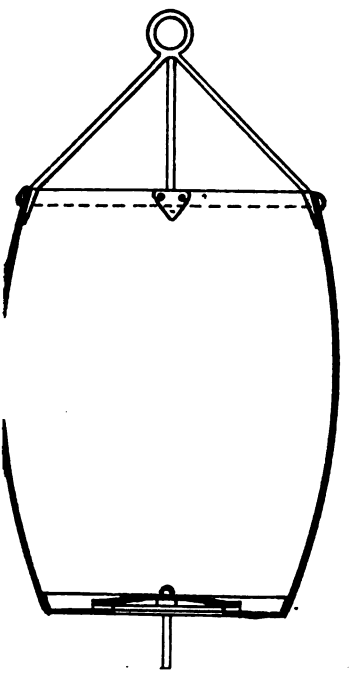

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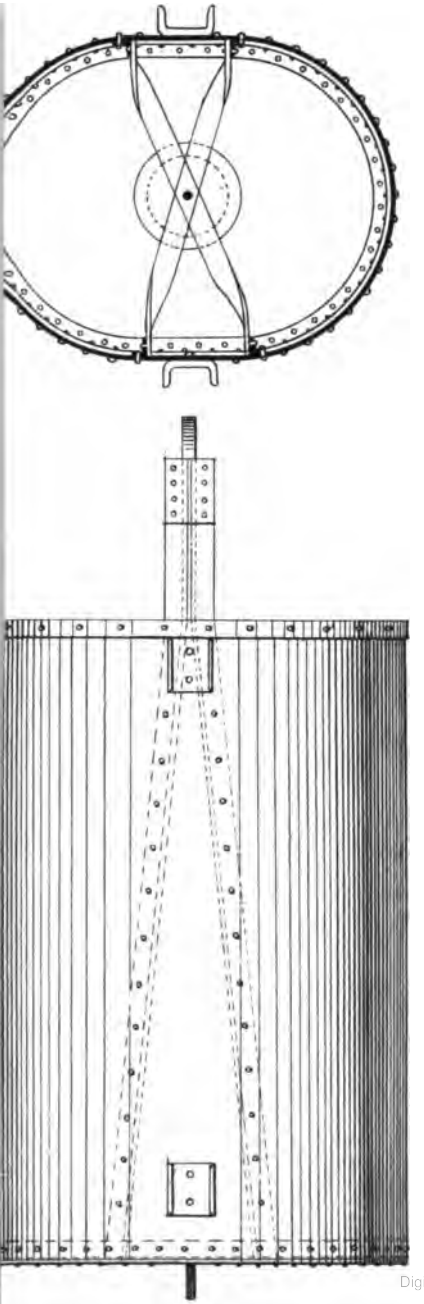

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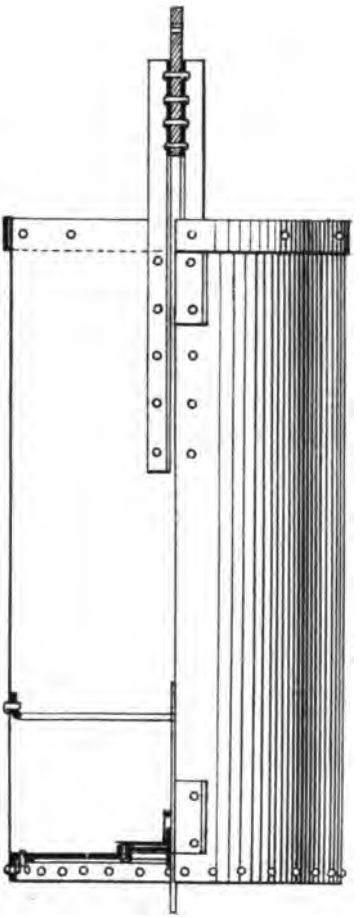

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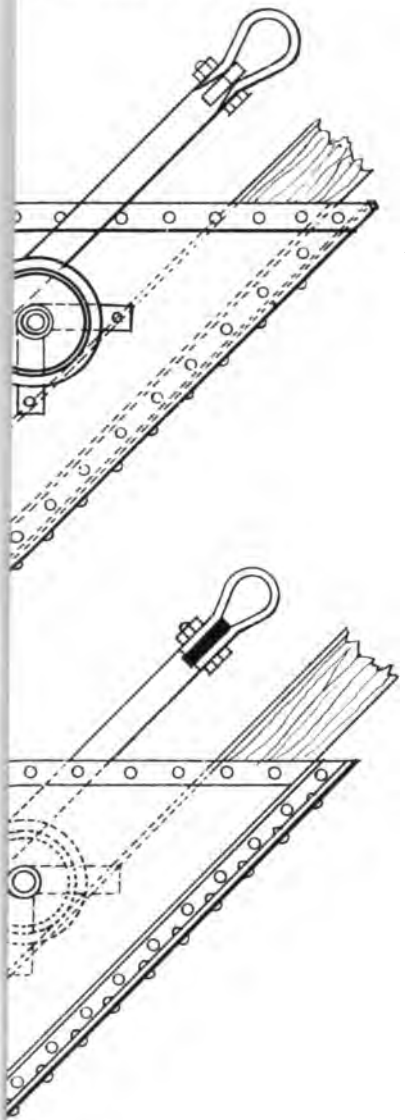

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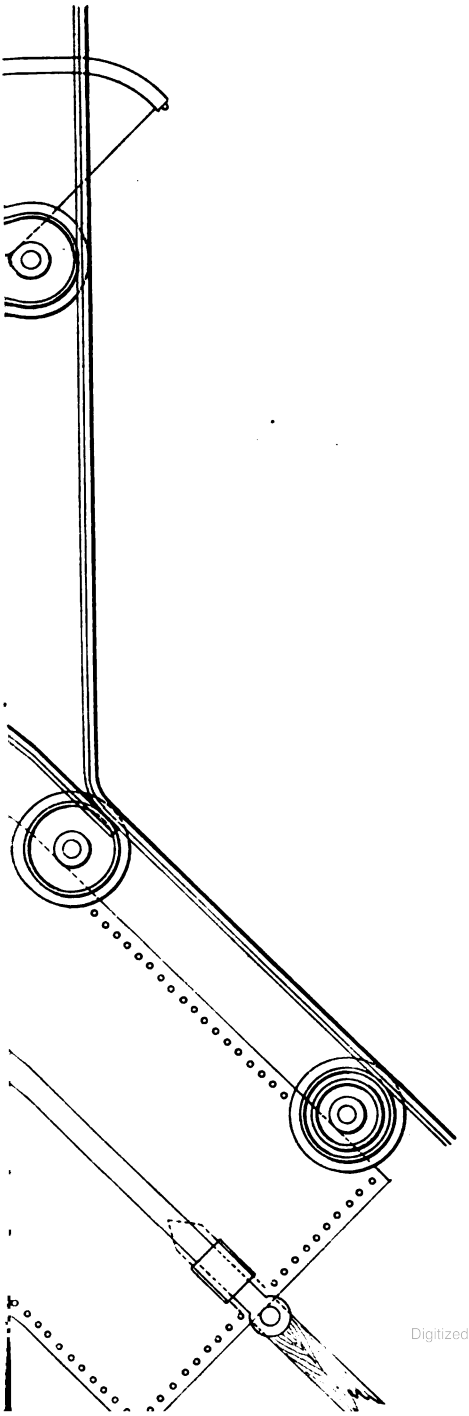

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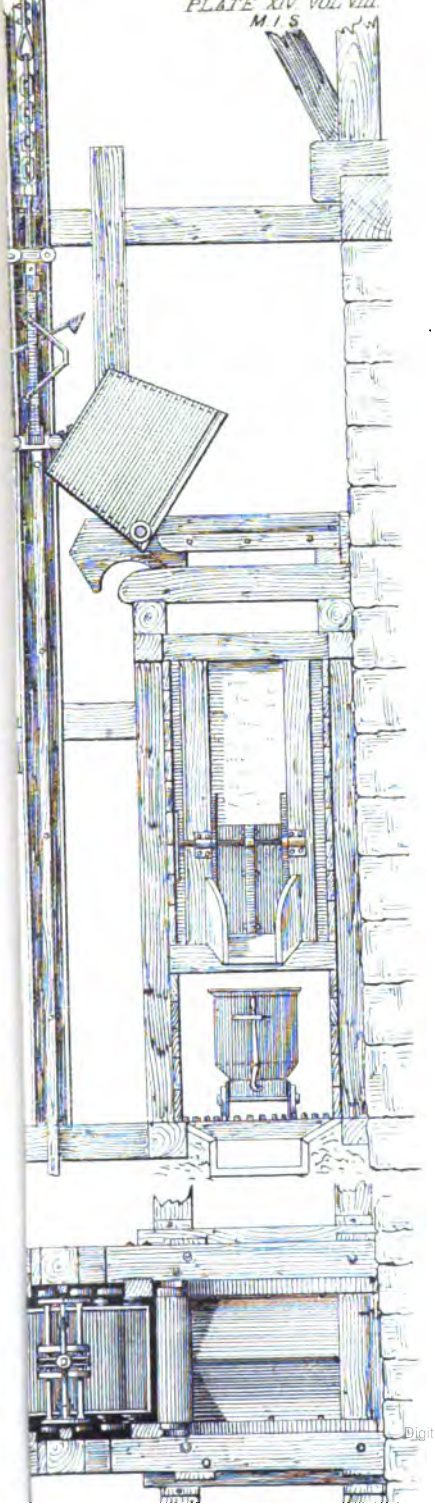

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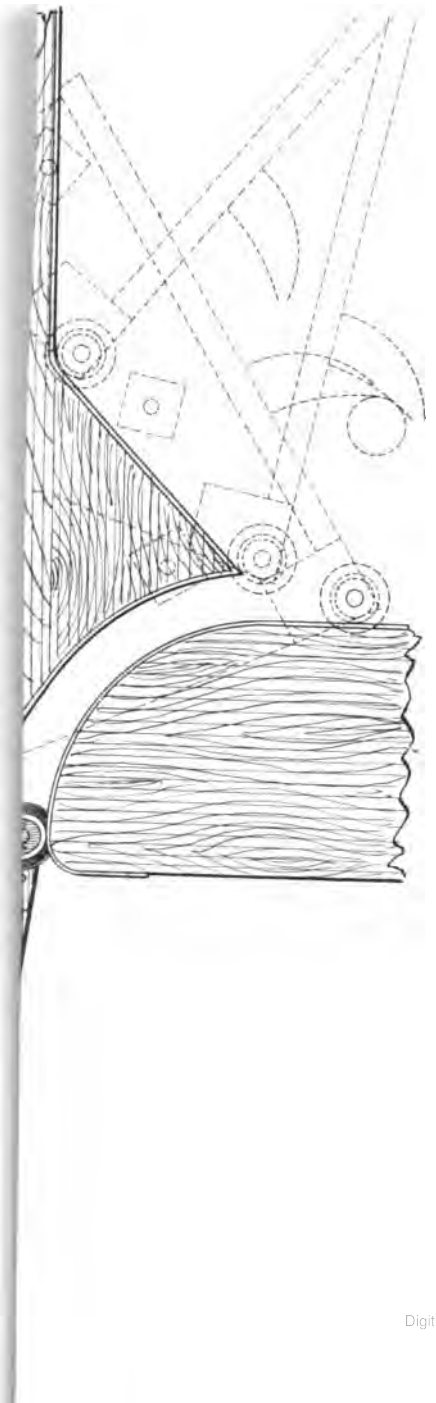

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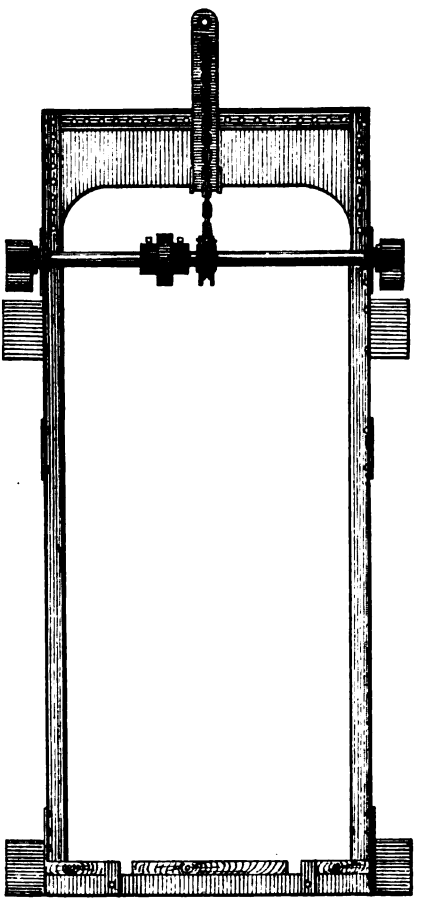

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THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

8th July, 1886.

JAMES S. DIXON, Esq., President, in the Chair.

Fully 30 Members were present.

The Minutes of the last General Meeting were read by the Secretary and confirmed.

The following were elected by ballot as Ordinary Members :—

WILLIAM HOWATT, Southrigg Colliery, Armadale.
ALEXANDER MURDOCH, 11 West Regent Street, Glasgow.
JAMES GREIG, Arden and Browniesside Collieries, Airdrie.

Mr ALEXANDER M. GRANT, Engineer, Kilmarnock, was elected a Councillor in room of Mr Blyth, who had been appointed Treasurer.

The following Report by the Committee on Experiments with Burnett's Patent Roller Mining Wedge and Drilling Machine was then read by the Secretary :—

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REPORT OF EXPERIMENTS WITH BURNETT'S PATENT ROLLER MINING WEDGE AND DRILLING MACHINE, MADE AT GREENFIELD COLLIERY, HAMILTON, ON 3RD, 5TH, AND 6TH JULY, 1886.

THE Committee have now the pleasure of laying before the Institute the result of a number of trials of Mr Burnett's Wedge and one of his Drilling Machines in the Main, Splint, and Ell seams, at Greenfield Colliery :—

WEDGING EXPERIMENTS.

The first series of wedging experiments (Nos. 1-3) were made in the Main coal, Whitehill Pit. Depth from surface, 123 fathoms. Section of seam :—

Fakes.	Ft.	In.
Free Coal,	0	11
Splint ,,	0	2
Free ,,	1	10
Hard Splint,	0	8
Free Coal,	0	7
	4	2

Bastard Fireclay.

Good parting at top and bottom of seam.

Experiment No. 1 was made in a plane which had been holed, and shorn on the left side. One wedge hole had also been drilled and the wedge placed in position.

DESCRIPTION OF PLACE.	Ft.	In.
Width of plane,	12	0
Height ,,	4	2
Holing—Depth,	4	0
Height at front,	1	6
Shearing—Depth,	3	6
Width at front,	1	2
Wedge hole—centre of hole from fast side,	1	7
,, from roof,	0	4½
Depth of hole,	3	8
Diameter, ,,	0	4½

One gib at nose of shearing.

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TIME.

Commenced to screw wedge—one man with double-power lever, ...	11.57 A.M.
Coal "working,"	11.58½
Gib drawn, ...	12.0½ P.M.
Stopped screwing wedge and dropped coal with a pinch, ...	12.15
Time of wedging, ...	18 minutes.
Coal brought down, including holings and shearings, ...	5 tons, 15 cwts.

Experiment No. 2 was also made in a plane, prepared similarly to last, but with the shearing on the right side.

DESCRIPTION OF PLACE.	Ft.	In.
Width of plane, ...	11	6
Height ,, ...	4	0
Holing—Depth, ...	4	6
Height at front, ...	1	10
Shearing—Depth, ...	4	2
Width at front, ...	1	4
Wedge hole—Centre of hole from fast side, ...	1	10
,, ,, from roof, ...	0	4
Depth of hole, ...	3	9½

No gib used.

TIME.

Commenced to screw wedge, ...	12.21½ P.M.
Coal "working"...	12.23½
Coal down,"	12.32½
Time of wedging, ...	11 minutes.
Coal brought down, including holings and shearings, ...	6 tons.

Experiment No. 3 was made in an end shorn on left side. Two wedges were applied.

DESCRIPTION OF PLACE.	Ft.	In.
Width of end, ...	14	0
Height ,, ...	4	0
Holing—Depth at open side, ...	4	0
,, fast side, ...	4	3
Height at front, ...	1	10
Shearing—Depth, ...	3	10
Width at front, ...	1	10
Wedge Holes—No. 1 from fast side, ...	2	0
No. 2 ,, ...	6	3

One gib at nose of shearing.

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TIME.

Commenced to screw both wedges, ...	12.40 P.M.
Coal "working,"	12.40½
Stopped No. 2 wedge, ...	12.44
Took out gib, ...	12.45
Coal down, ...	12.48
Time of wedging, ...	8 minutes.
Coal brought down, including holings and shearings, ...	5 tons, 14 cwts.

The second series of wedging experiments (Nos. 4-7) were made in the Splint coal, No. 2 Pit, Greenfield, where the Splint and Virgin seams are close together. Depth from surface, 143 fathoms. Section of seam :—

Coal roof left on in first working.	Ft.	In.
Free coal, ...	0	4
Splint coal, ...	1	3
Splint coal, ...	0	6
Parrot and Splint, ...	0	3
Free coal, ...	1	5
Stone parting, ...	0	1
Virgin coal, ...	0	5
Parting, ...	0	0
Virgin coal, ...	3	2
	5	10

Fakes.

Experiment No. 4 was made in an end shorn on left side, and in the Virgin portion of the seam only, the seam being worked in two "carries" or sections, and the bottom section taken first.

DESCRIPTION OF PLACE.	Ft.	In.
Width of end, ...	12	6
Height, ...	3	8
*Holing—Depth, ...	3	8
Height at front, ...	1	2
Shearing—Depth,...	3	2
Width at front, ...	0	9
Wedge Hole—From fast side, ...	2	6
Centre of hole from roof, ...	0	2
Depth of hole, ...	3	8

* One man, 8½ hours holing and shearing.

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TIME.

Commenced to screw wedge, ...	12.11½ P.M.
Coal down (except small corner at fast side),	12.14¼
Time of wedging, ...	2¾ minutes.
Coal brought down, including holings and shearings, ...	... 4 tons, 18 cwts.

Experiment No. 5 was made in a plane in the Virgin coal, shorn on left side.

DESCRIPTION OF PLACE.	Ft.	In.
Width of plane, ...	11	0
Height ,, ...	3	10
Holing—Depth, ...	3	6
Height at front, ...	1	1
Shearing—Depth, ...	3	4
Width at front, ...	1	4
,, at back, ...	0	6
Wedge Hole—From fast side, ...	2	3
Centre from parting, ...	0	4
Depth of hole, ...	3	8

TIME.

Commenced to screw wedge, ...	12.25 P.M.
Bulk of coal down, ...	12.33
Continued screwing wedge, ...	
Pinch applied, ...	12.35½
Remainder of coal down, except in fast corner,	12.37
Time of wedging, ...	12 minutes.
Coal brought down, including holings and shearings, ...	4 tons, 7 cwts.

Experiment No. 6 was made in a plane in the Virgin coal, shorn on the left side.

DESCRIPTION OF PLACE.	Ft.	In.
Width of plane, ...	11	0
Height ,, ...	3	9
Holing—Depth, ...	4	0
Height at front, ...	1	4
Shearing—Depth, ...	3	4
Width at front, ...	1	4
Wedge hole—from fast side, ...	2	0
Centre of hole from parting, ...	0	3
Depth of hole, ...	3	8

One gib at nose of shearing.

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TIME.

Commenced to screw wedge (one man), ...	12.42 P.M.
Wedge very stiff to work, two men applied, ..	12.44½
Fast side relieved with pick, ...	12.51
Gib drawn, ...	12 53
Pinch applied and bulk of coal dropped, ...	1.7
Remainder of coal down, ...	1.10
Time of wedging, ...	28 minutes.
Coal brought down, including holings and shearings, ...	4 tons, 5 cwts.

NOTE.—On the wedge being examined, it was found to have been jamming.

Experiment No. 7 was made in the top carry of the working, on the end course of the coal.

DESCRIPTION OF PLACE.	Ft.	In.
Thickness of carry, ...	2	0
Total breadth of place, ...	12	6
Breadth of section wedged, ...	9	0
Wedge hole—from left side, ...	4	5
Centre of hole from top, ...	0	2
Depth of hole, ...	4	4

TIME.

Commenced to put in wedge, ...	1.20 P.M.
Commenced to screw on double power, ...	1.22
Pinch applied, ...	1.29
Coal down, ...	1.31
Time putting in wedge, ...	2 minutes.
Bringing down coal, ...	9 ,,
Total, ...	11 minutes.

The coal was burst down at the centre of the 9 feet section, tapering off on both sides; 17 inches of the hole left on.

Total coal brought down, 1 ton, 10 cwts.

The third series of wedging experiments (Nos. 8-10) were made in the Ell coal, Whitehill Pit. Depth from surface, 110 fathoms. Section of seam:—

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Hard freestone.	Ft.	In.
Free coal,...	0	11½
Hard Splint, ...	0	2
Free coal, ...	2	2
Splint, ...	0	6
Free coal, ...	1	2½
Stone, ...	0	3½
Bottom coal, ...	2	0
	7	3½

Bastard fireclay.

The seam has a bad parting from the roof. It is worked in two carries—the top section (above the stone) first.

Experiment No. 8 was made in a plane in the upper section of the seam. The place was shorn on the left side, and two wedges were employed.

DESCRIPTION OF PLACE.	Ft.	In.
Width of plane, ...	13	0
Height ,, ...	4	10
Holing—Depth, ...	5	6
Height at front, ...	2	0
Shearing—Depth, ...	4	3
Width at front, ...	1	3
Wedge holes—No. 1 from fast side, ...	2	1
Centre of hole from roof, ...	0	7
Diameter of hole from roof, ...	0	5⅛
No. 2 hole from No. 1,...	5	6
Centre of hole from roof, ...	0	6
Diameter of hole, ...	0	4½
Depth of holes, ...	3	10

TIME.	
Commenced to screw No. 1 wedge, ...	11.55 A.M.
Coal "working,"	11.57
Started No. 2 wedge, ...	12.0
Stopped No. 2, continuing No. 1, ...	12.2 P.M.
Started No. 2, ...	12.4
Stopped No. 2 (a few turns given subsequently),	12.5½
Pinch applied and coal brought down, ...	12.12

The coal was brought down from the level of the wedge holes. Three feet of No. 1 hole, and two feet four inches of No. 2 hole

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were brought down, the break sloping backwards towards the pavement. A portion of coal was left on next the shearing, and also some in the fast corner.

Time of wedging, ...	17 minutes.
Coal brought down, including holings and shearings, ...	4 tons, 5 cwts.

Experiment No. 9 was also made in a plane in the upper section of the Ell coal. The place was shorn on left side, and two wedges were employed.

DESCRIPTION OF PLACE.	Ft.	In.
Width of plane, ...	12	0
Height ,, ...	4	10
Holing—Depth, ...	4	6
Height at front, ...	1	10
Shearing—Depth,...	4	6
Width at front, ...	1	6
,, back, ...	0	6
Wedge holes—No. 1 from fast side, ...	2	0
Centre of hole from roof, ...	0	6
No. 2 hole from No. 1, ...	5	0
Centre of hole from roof.	0	6
Diameter of holes, ...	0	4½
Depth ,, ...	3	8

TIME.

Commenced to screw both wedges, ...	12.27 P.M.
Coal "working" immediately.	
Coal down, ...	12.34

Two feet nine inches of both holes was brought down. Some coal was left sticking to the roof, and some at the side of the shearing.

Time of wedging, ...	7 minutes.
Coal brought down, including holings and shearings, ...	5 tons, 5 cwts.

Experiment No. 10 was made in the top section of the Ell coal, in the pillar working or stooping, and on the plane course of the coal. The slice, or jud, was loose at right side, and forty-five feet from the corner of the stoop. One wedge was employed.

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DESCRIPTION OF PLACE.	Ft.	In.
Length of jud, ...	22	0
Height ,, ...	5	0
Holing—Depth, ...	4	6
Height at front, ...	1	8
Wedge hole—from fast side, ...	2	0
Centre of hole from roof, ...	0	6
Depth of hole, ...	3	8

Three gibs had been inserted, two of which were drawn before commencing to wedge, the remaining gib being eight feet distant from the wedge hole. A small portion of the jud was left unholed at the loose end.

TIME.

Commenced to screw wedge, ...	1.5 P.M.
Gib drawn, ...	1.7
Pinch applied, ...	1.12
Coal down, ...	1.13

2 ft. 10 in. of hole down. Jud down all along the holing.
Time of wedging, ... 8 minutes.
Coal brought down, including holings and shearings, 9 tons.

DRILLING EXPERIMENTS.

THE machine used in these experiments was the hand-drilling machine described on p. 32, and shewn on plate VI.

Experiment No. 1 was made in the Main coal, on the end course of the seam.

TIME.

Commenced to drill (two men), ...	12.51 P.M.
Stopped to change drill, ...	12.58
Re-started drilling, ...	12.59
Stopped, ...	1.7

	Ft.	In.
Size of drill, ...	0	4½
Depth of hole, ...	3	10
Time of drilling,...	16 minutes.	

The drills had previously bored four holes. On the long drill

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being withdrawn, a piece was found to have been broken off at the point by "brass" in the coal, which caused the time of drilling to be longer than usual.

Experiment No. 2 was made in the roof stone or grey fakes above the Main coal.

	TIME.	
Commenced to set machine, ...	1.10 P.M.	
Commenced to drill, ...	1.18	
Stopped to change drill, ...	1.22	
Re-started drilling, ...	1.26	
Stopped, ...	1.28	
		Ft. In.
Size of drill, ...		0 2¼
Depth of hole, ...		3 3
Time occupied setting machine, ...	8 min.	
Drilling, ...	10 ,,	
Total,...	18 ,,	

Experiment No. 3 was made in the Virgin coal, on the end course of the seam.

	TIME.	
Commenced to set machine, ...	1.38 P.M.	
Commenced to drill, ...	1.39½	
Touched coal, ...	1.40¦	
Stopped to change drill, ...	1.42	
Re-started drilling, ...	1.44	
Stopped, ...	1.49½	
Machine down, ...	1.51	
		Ft. In.
Diameter of hole, ...		0 4½
Depth ,, ...		3 8
Time occupied setting machine, ...	1½ min.	
,, taking down machine, ...	1½ ,,	
,, drilling hole, ...	10 ,,	
Total, ...	13 ,,	

This was the second hole bored after the drill had been sharpened.

Experiment No. 4 was made in the upper section of the Ell coal on the end course of the seam.

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TIME.

Commenced to set machine (three men), ...	12.49	P.M.
Commenced to drill (two men), ...	12.52½	
Stopped to change drill, ...	12.56	
Re-started drilling, ...	12.58	
Stopped, ...	1.1	
Machine down, ...	1.3	

	Ft.	In.
Diameter of hole, ...	0	4½
Depth, ...	3	8

Time occupied setting machine, ...	3½	min.
,, taking down machine, ...	2	,,
,, drilling hole, ...	8½	,,
Total, ...	14	,,

These experiments cannot but be regarded as demonstrating the great power and efficiency of Mr Burnett's wedge. In the Main and Virgin coals particularly, where the parting above was good, and also in the experiment in the Ell coal stooping, the "juds" were brought down in nearly all cases with a single wedge, rapidly, and in excellent condition. In the Ell coal solid working, on account of the greater strength of the carry and the bad parting from the roof, two wedges were required, and the juds were not brought down quite so effectively.

The experiments with the drilling machine showed that the holes required for the wedges, though of the considerable diameter of 4½ to 5 inches, can be bored out in ten to fifteen minutes, which is probably the most expeditious hand-machine boring on record.

On the whole, though the wedge is somewhat heavy to handle, and cannot perhaps be applied with the same facility as gunpowder, it cannot be doubted that the coal is brought down in better marketable condition; while the fact of the wedge being absolutely free from any of the risks attending shot-firing, commends it specially to the attention of those who from the circumstances of the case, require to bring down coal without the use of powder.

Reported by JAMES BARROWMAN.
ROBERT L. GALLOWAY.
JAMES HASTIE.

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DISCUSSION.

Mr BURNETT, at the request of the President, described the different machines, one of each was shewn in the room, and discussion having been invited,

Mr SMART said the Report by the Committee seemed to be very exhaustive. He noticed that the quantity of coal brought down was something very satisfactory, but he was unable from the wording of the Report to gather whether or not the quantities of coal and dross were detailed separately. He thought it would have been satisfactory to have learned the percentage of dross to the quantity of coal taken down.

The SECRETARY said the coal and the dross had not been given separately. There was some little difficulty in doing that. They might understand that a few experiments would not be sufficient to give a satisfactory result with regard to that matter. It could only be by comparing what was actually done by wedging by hand or in the ordinary mode of mining as compared with what was done by the wedging machine in the same pit and circumstances that a proper comparison could be made, and the Committee had not an opportunity of making them so exhaustive as to accomplish this end.

Mr ROBERT BEITH said, seeing there had been ten experiments, it was a pity an effort had not been made to ascertain the percentage of dross. That was a matter of importance, because they were aware of the large stooping operations in their midst and the high percentage of dross which it entailed; and by getting at this as regarded the wedging machine they would get out of the difficulty. With regard to the boring machine, he was there the whole three days and was thoroughly satisfied with the results. As to the wedging of the Main coal, there was a splendid parting, and the machine wrought first class. In the Ell coal the parting was rougher. The machine did not do the same work; still, it brought the thing down. From what he had seen he thought there would be a future for the machine; but he thought it a pity that they could not give the percentage of dross.

Mr HASTIE said the dross from the holing and shearing was

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sent up the pit and weighed, and then the coal brought down by the wedge was taken up and weighed as it was brought down. There would be a certain amount of dross in it.

Mr GALLOWAY said the round coal and dross were so mixed up they could not keep a separate note of them.

Mr JAMES SMART said, perhaps Mr Hastie would say what he considered, by looking at it, the proportion of round coal and dross with the machine as against the ordinary method of shot-firing.

Mr HASTIE said, those present at the experiments saw this for themselves. As far as the Main coal was concerned, the coal was certainly better than with shot-firing. It came all down in a lump, and if the coal had been measured he believed it would have shown between four and five tons of coal. The Virgin coal was a seam in which gunpowder was never used; but in the second and third trials the coal was as good for roundness as ever came out of the pit. In the Ell, it was weighed as it was brought down with the wedge, but there would be a little dross in the coal if riddled. In the special place at the stooping anyone could calculate it for himself if he took the measurements.

Mr GALLOWAY—There was some dross in breaking up.

Mr HASTIE—Yes, in breaking up the coal.

Mr BEITH—In the tenth experiment, the committee state 9 tons of coal. Would 75 per cent. be a fair average?

Mr HASTIE—I would make it a great deal more.

Mr BEITH—80 per cent.

Mr HASTIE—Fully 80 per cent. He had made a good many experiments himself, and got from 60 to upwards of 80 per cent. of round coal.

Mr DAVID ANDERSON remarked that a good deal of what was taken out in the shearing and holing if passed over a scree would come out as round coal. He did not think it would be fair to say all taken out in that way was dross. He thought the comparison should begin after the holed and sheared coal were cleared away; and if there was 80 per cent. after that it looked like a satisfactory result, especially as the coal was not so much broken up as with the ordinary blasting. He did not know in a close place, with a powder shot at both sides, how the comparison might have stood

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against this machine. The objection was taken, that the boring machine did not bore the holes quite close enough to the roof. Looking at it, he thought it was scarcely possible that it could, for by the time the thumb screw got up to the wedge it could not be worked.

Mr BURNETT said as the machine stood a good deal higher, the thumb screw in the circumstances suggested would be up to the roof. The drill was 4½ inches diameter, and although it would go up to the roof in the ordinary position, they tried it at a higher inclination as it gave better results. If necessary they could raise it higher. It was only required to insert the tension bolt from the top and put the thumb screw at the bottom.

The PRESIDENT—Some of the holes were an inch or so out of the roof.

Mr ANDERSON thought the cause of that was simply the objection he took to the machine.

Mr BURNETT said what was stated was correct, that the drill in the top position would not make a strictly horizontal hole, but the bar by being slightly inclined would at any time bring it to the roof. In fact, they had to guard against this in actual practice.

Mr GALLOWAY—In one case the centre of the hole was only two inches from the roof at the front.

Mr HASTIE—We have drilled a great many holes, and we found that in a 3 feet hole it was up into the roof at the inner end.

Mr BEITH—You would find that quite satisfactory ?

Mr HASTIE—Oh, yes; it was just a matter of regulating the beginning of the hole. There were several times that the hole touched the roof before they got in, and they had to start a new hole.

Mr ANDERSON—It certainly could be run better in a parallel line with the thumb screw down below than with it on the top.

Mr JAMES GILCHRIST said it struck him from what had passed that the Committee had still some things to do in connection with these machines. No doubt it was a very important invention, but to enable them to judge correctly, a comparison should be made with Mr Burnett's wedge and coal got by ordinary wedging

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and by powder. If the Committee had asked the liberty, he had no doubt they would have been allowed, to have the coal riddled in a place running parallel to where the wedge was tried, and then have riddled the coal brought down by the wedging. They would thus have got at facts no one could have gainsaid, and it would have had a very important bearing on the trials made. Possibly this could be done yet. If so, it would be satisfactory to every one. He was very much pleased with the trials he saw at Greenfield, and they certainly compared very favourably with those made with the lime cartridge at Earnock Colliery. There was no doubt the machine brought down the coal better than the lime cartridges did; and he thought it was only justice to Mr Burnett that that should be admitted. It might be of some interest were he to relate some trials he made four years ago at Earnock, and it would also illustrate the necessity for riddling the coal in each place. He was requested to make trials to see whether the ordinary system of wedging would not produce rounder coal than that produced by powder. He said at once they could not wedge them as satisfactorily as where powder was used. However, he got instructions to try the experiment and at once went on with it. He selected two places with two men working in each who were average examples of really good colliers. The arrangement he made with them was that they would riddle all the coal at the face with a riddle having a mesh an inch and a half square. They were to riddle all the coal got by powder for a fortnight, and at the end of that time were to commence to hole the coal and shear and wedge it down in the ordinary way. The first fortnight in one of the places two of the men got with powder 107 tons of round coal and 24½ tons of dross. The percentage of round coal was 81, and dross 19. He might state that the place was being driven on end. The second fortnight, without powder, they only got 81½ tons of round coal, and 20 tons 7 cwt. of dross, the percentage of dross and coal being very similar, viz., 80 per cent. of round coal and 20 of dross. The second trial was made in a cross-cut place where the coal was more difficult to get. The percentage for the first fortnight with powder was 80 per cent. of round coal and 20 of dross. The second fortnight, by wedging, the

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round coal got was 74½ per cent., and dross, 25½ per cent. The men in the second place were quite beat off, and had to give in after working nine shifts. It might be important to notice that in the trials the men produced with gunpowder on an average 9 tons 9 cwt. per shift, while in wedging they only produced 7 tons 5 cwt. The trials were carried out very impartially, and he was satisfied from the workmen he employed they did everything that could be done. He arranged before-hand that they would lose nothing on it, so they had no interest one way or another. He thought if the Committee had adduced facts something like these they would have been of use.

Mr GALLOWAY said he quite agreed with Mr Gilchrist that it was of importance to ascertain the percentage of round coal to dross. However, the Committee only got the weight that afternoon. They understood the weight of the dross and round were being kept separate, but found that this had not been done.

Mr ANDERSON said if there were to be any further experiments, instead of having the coal riddled, as Mr Gilchrist suggested, at the face, he would have it passed over the ordinary scree on the pithead. He had seen coal riddled in the pit, and there was a way of riddling it that left a great deal of small. He thought the pithead scree would be a better test.

Mr HASTIE said he would like to know how they would take the percentage over the whole work for a fortnight with several seams of coal working in the same pit.

Mr GILCHRIST said he quite agreed with Mr Anderson as to passing the coal over the scree being the best, but in using the riddles in the cases he had mentioned, it was used in both cases, and in that way the one was a fair comparison with the other. He agreed that it did not bring out a fair percentage otherwise.

The PRESIDENT said there must have been special care in both cases in driving, for they knew that ordinarily the percentage of dross was very different from what was now stated. He would suggest that, as Mr Russell and Mr Hastie had had a great deal of trouble, and it was desirable that experiments should be made elsewhere,

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Mr Gilchrist might endeavour to get Mr Watson to continue them and have the dross and round coal weighed and compared one with another.

Mr GILCHRIST did not think it necessary that they should go to Earnock as he understood Mr Burnett had made arrangements to conduct experiments at Bent.

Mr BEITH—And the "Billy-Fairplay" is not at Earnock, and is at Bent.

The PRESIDENT said that one difficulty was that they did not use powder in the Ell coal at Bent, so they would need to start a new system of working that they were not accustomed to.

Mr ANDERSON said it might be thought he had some objections to the machine from the remarks he made criticising the drill. He thought rather that it was about as good a thing of its kind he had seen. In many cases, in starting stooping, they could not get using powder very well. In this case, the two experiments in the solid coal, he did not think were quite as satisfactory as they might have been, simply because the hole was not so near the roof. The difference was not very much, but in the case at the stooping there was a longer wing of coal to bring down, and it was not holed through at the open end. It appeared to him that the experiments, as far as they went, showed that this might be a very useful tool indeed for carrying on operations in any place where it was objectionable to have blasting with powder. Certainly, whatever the percentage might have been, if the quantity had been correctly weighed,—whether 80 per cent. or whatever it was,—the coal appeared to be very little fractured, and quite in a good marketable condition.

The PRESIDENT said he was present at the experiments one of the days, and he was very much pleased indeed with both the drilling and wedging machines. He quite concurred that in many instances this machine might be of very great use, and his general impression was that the coal was brought down in excellent marketable condition. There was one material difficulty, in applying it generally. The coal was particularly well prepared by holing and shearing. Now, they knew the practice in the Hamilton district was that the colliers did not do that. They

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would require to train their colliers better before they could adopt it. That was a great difficulty. In many cases where it was absolutely necessary not to use powder, from the presence of gas, it might be the less of two evils; but as a general rule he was afraid that would be found to be the greatest difficulty in the adoption of the machine. At the same time the long-wall might be so laid out as to work the machine to advantage.

Mr BEITH said the question would come to be how many places would two men wedge with it? According to what the President had said, they would require to depart from their present system of working. Unless they had a number of places, they would require to prepare all the places,—that is to say, hole and shear them,—at night and begin and wedge them down in the morning. He thought unless they had an extra number of places, that would require to be done.

Mr HASTIE said the time given for the two men to set the drill, bore the holes and wedge down was explained, as shewn by the time taken to do one hole, and he thought two men in eight or nine hours would do eight or nine holes.

Mr GILCHRIST did not think there would be any real difficulty in the way of preparing the coal, and it occurred to him that the coal at Bent was tender, and that would explain why they did not use powder there. If they had to use powder the miners would see the necessity of preparing their coal very well. That was his experience. Their workmen in the solid places as a rule prepared their coal very well indeed. They were forced to do it or their powder would not work. There might be greater difficulty in shearing. There were not so many accustomed to shearing as there used to be, and for a little time there might be a little difficulty in doing that. But if the coal-getting depended on holing and shearing, in a short time they would see it to be to their advantage to prepare their places in the best way. He saw the drill boring machine at work, and the only thing he was disappointed with was that it was not tried in harder rock. Of course, in boring the coal, it was right enough, but in boring the roof of the Main Coal, it seemed to him to be soft, and that the ordinary drill in the same circumstances would have drilled the hole and possibly

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not taken much more time. They must also take into consideration that there were three men working the machine, while with the ordinary drill one man would have done it.

The PRESIDENT—Can Mr Burnett give us the cost?

Mr BURNETT—£18 for the drill and £17 10s for the wedge.

Mr ANDERSON asked Mr Burnett how he explained that to which Mr Gilchrist referred, viz., the number of men required.

Mr BURNETT—I am not aware that there were three men working the machine.

The SECRETARY said three men were not required. It so happened that during the drilling trials there were two men turning the handles and one attending to the drill, but two men would do quite well.

Mr JOHN HOGG said in one of the experiments it was found that the wedge jammed. Was that likely to happen often, or was it an exceptional case? In regard to the boring machine, would it not be an advantage that it should be made so that the hole would be quite close to the roof? He might say, in regard to the holing of the coal, that at North Motherwell the Ell coal had to be holed from 3½ to 5 feet, so that that would not be an objection so far as they were concerned there, and probably it was the same with many others.

Mr BEITH, in reference to the boring close to the roof, said it would be very good if the roof was always level, but the roof was not always so, and if they met with one of those "rows" of rock which occasionally come in, it would very likely render the drill useless. Perhaps that was the way they did not go so close to the roof.

Mr BURNETT said the holes could be drilled close to the roof, and were practically drilled close to the roof. In fact, there was a danger of running into the roof. Referring to the remarks of the President as to the apparent necessity for special holing and shearing, prior to coming here their experiments were confined to holings of 2 feet 6 inches and 3 feet, and he would undertake to go into any of the pits of the district and take any of the places haphazard and detach the coal. It was not

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for want of power a good holing was desired, but it gave a better result, and it was to the advantage of the miner to make the holing good. For the Virgin and Main coal seams, he quite expected, with another wedge of the same type as the one now exhibited, that they would be able to dispense with shearing altogether. He was very anxious to show it as early as possible. As to what Mr Beith and Mr Smart had said in respect to the percentage of dross, whilst he was pleased with the report, he must say he was rather disappointed it was not mentioned, because the weights submitted showed the amount of round coal and the amount of dross, as weighed separately, were in the Main coal workings an average of 84 per cent. of round coal, about 79 in the Virgin, 76 and 72 in the Ell, respectively, and 88 in the Ell stooping.

Mr GALLOWAY said this did not give the dross and the round coal per ton in the coal wedged down.

Mr BURNETT understood that the whole of the dross, both in the holing and wedging, was filled and weighed separately, and that the dross was represented by such coal as would pass through an inch-and-a-half mesh.

Mr HASTIE said the coal wedged was all weighed together. There was a little dross, but not so much as was to be expected in an inch-and-a-half scree.

Mr BURNETT said he should like if Mr Gilchrist would say whether he had continued to adopt the system that he referred to of wedging, or was it powder those remarkable results were obtained with?

Mr GILCHRIST said in all the places where he saw the experiments made, the head coal was very well dressed. After the coal was brought down, the place was left very rugged, and before the wedges could have been introduced a good deal of dressing must have taken place to leave it in as good condition, and in doing so more dross would be made. As to the experiments he gave, in the first case there were twelve working days,—that was to say, the trials with powder extended over twelve days, and the trials with the wedging extended over other twelve days. In the second case they lasted eleven days with powder, and nine with the wedging; and from the quantities

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given it would be at once seen that it cost a great deal more to wedge it than to bring it down with powder,—he thought, speaking from memory, something like 6d a ton.

Mr HASTIE asked what the cost was of working in the ordinary way compared with blasting?

Mr GILCHRIST said any one could count it for himself. Blasting was the ordinary way of working. They got by blasting 107 tons of round coal and 24 tons 9 cwt. of dross for twelve days; working for twelve days with the wedges only 81 tons 9 cwt. and 20 tons 7 cwt. of dross. In the first case with powder, they had 131 tons 10 cwt., and in the second fortnight with wedges 101 tons 16 cwt.—a difference of about 30 tons.

Mr ANDERSON asked if the cost per ton was the same for mining 131 with powder as for the 101 without it?

Mr GILCHRIST said when he asked them to riddle the coal at their faces, he provided them with a riddle, and arranged to pay them extra for riddling the coals. Then, in working with the wedge, he had to make up what they lost.

The SECRETARY said the two could not be compared.

Mr ROBSON thought it useless to compare one or two experiments with the ordinary working. The proper test would be to work it continuously for two or three months and compare that.

Mr BURNETT endorsed what Mr Robson had said, and said he should be happy to give the use of wedges and drilling machine and one man to carry out the experiments continuously for a fortnight or three weeks, the trials to take place in each of the three seams of the district. Referring to what Mr Gilchrist had said as to the squaring out of the place, he thought he was justified in saying that with two exceptions—that was the two places in the solid working of the Ell seam—the coal fell off square at the back.

Mr GALLOWAY—The committee refer to that in the conclusion of their report.

The PRESIDENT, in adjourning the discussion, said he was very much pleased with both the machines, and he thought the wedges

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powerful instruments. With regard to his remarks about the preparing of the places, they were made with reference to the Ell coal stooping.

Mr HASTIE said there were a number of experiments which he made of which Mr Burnett did not get full advantage. He never gave him the advantage of what did not come down. In some cases there was a bit coal left on, and in the two Ell coal places which the committee saw, he got no credit for what was left on.

The discussion was then adjourned.

Mr JOHN GEMMELL then read the following paper on "The Work of the Royal Commission on Accidents in Mines:"—

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THE WORK OF THE ROYAL COMMISSION ON ACCIDENTS IN MINES.

By JOHN GEMMELL, Mining Engineer.

In the year 1879, a Royal Commission was issued, practically for the purpose of determining whether the resources of science furnished any means, not then in use, whereby accidents in mines could be prevented or their disastrous consequences limited.

The Commission was composed of practical men like Sir George Elliot and Mr Lindsay Wood, and of men distinguished in experimental science like Professor Tyndall, of natural philosophy fame, and Sir Frederick Abel, chemist to the War Department at Woolwich. There was also what might be looked upon as a representative of the working miner in the person of Mr Burt; and Mr Warrington Smyth, lecturer on mining at the Royal School of Mines, and inspector of Crown minerals, acted as chairman.

The Commissioners issued a preliminary report in 1881, and their final report in March last. The inquiry thus extended over seven years. These reports are only published in Parliamentary Blue Books, so that the information they contain, and which has been gathered at a considerable expenditure of public money, is not in a very accessible form, and your secretary suggested that the results of the elaborate experiments which the Commissioners have carried out, and the information which they have collected, might be beneficially diffused among colliery officials, who have no opportunity of seeing these reports, by the preparation of a paper for this Institute. It may also serve as a basis for the discussion of the Commissioners' work, suggested by the President in his address.

Government inquiries into mining accidents are not exceptional, and although explosions of fire-damp are not the chief cause of mortality in mines, yet by claiming at one time such a large number of victims, they have agitated for themselves to such purpose that within recent years commissions have been appointed in France, Belgium, Prussia, and Saxony to investigate their cause and the means of mitigating their consequences. Reviews of the

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reports of the French Commission have been already brought under your notice by Mr J. H. Ronaldson and Mr R. T. Moore.

In order to determine in what direction to prosecute their inquiry, the Commissioners examined the fourteen inspectors of mines, many mining viewers and managers of experience, and also workmen selected by miners' associations. As representing Scotland, the late Mr Alexander and Mr Moore, and also Mr John Reid, Bredisholm, and Mr Ferrie, Monkland were examined.

The evidence, which forms a large volume, is very instructive. There are, however, many conflicting opinions. Men whose experience has been acquired in certain fiery districts would blast even where safety lamps were needed; others who have practised in regions subject to sudden outbursts, which no ventilation could cope with, would prohibit blasting altogether. Men from places with good roofs see no advantage in the systematic setting of timber; while others having experience of indifferent roofs would timber at stated distances whether the place appeared to require it or not. All this shows the imprudence of any rash generalization.

Another point running through the evidence is the tendency of men to rely on mechanical safeguards. Often is the opinion given that the introduction of safety lamps leads to neglect of ventilation; that the adoption of safety cages and detaching hooks leads to carelessness with respect to the examination of ropes, and neglect on the part of enginemen. To take care that safeguards are not neutralized in this way is the function of legislation, which enforces general rules for the securing of discipline by the sterner hand of the law.

The same experience has generally been bought, sometimes at considerable sacrifice, in each different coalfield. This may be due to the fact that coalfields are isolated, and the persons in charge in each had small means of communicating with one another. That is considerably altered now. Mining Institutes afford to colliery managers the means of coming together and exchanging views and experience, and to the emulation which is consequently fostered by these institutions and to legislation, which, as Mr Alexander well puts it, "tends to bring the inexperienced district to the level of the experienced"—the Commissioners

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chiefly attribute the great amelioration which has taken place in the condition of mines during the last thirty years. Roughly, during all that period, a thousand men have been killed every year; but that the amelioration is great is shown by the fact that although the annual mortality remains constant, the number of workmen employed has more than doubled.

The average from 1875 to 1884 was 1116 deaths. Of these 41 per cent., or 458, resulted from falls of roof and sides; 23 per cent., or 256, resulted from explosions of fire-damp; 36 per cent., or 402, resulted from miscellaneous causes.

The first main cause of accidents then, arises from falls of roof and sides, and the second chief source results from explosions; and while the Commissioners were of opinion that, for the diminution or limitation of these, the resources of science were most likely to afford practicable expedients, it may be imagined that the mining men among them would have a feeling that science would only apply in an inferior degree to the reduction of accidents from falls, which seem to lie more within the domain of ordinary caution and strict discipline.

Deaths resulting from falls have not been reduced in the same ratio as deaths from other classes of accidents. This would seem to indicate that they are to some extent the fixed constant in mining fatalities. They would be the only class of accident known to the earliest miners, and probably when science has altogether eliminated explosions, they will remain as the ordinary risk, which with grimest sarcasm the common law of our land dictates the miner must run, in consideration of the higher pay he receives.

Lamps, to reduce accidents from explosions, are covered and the light reduced, and there is evidence given to the effect that this reduction of light increases accidents from falls, as an examination of roof and sides cannot be so well made with the poorer light afforded by the safety lamp. To reduce accidents from explosions we may leave off blasting and adopt wedging; but if we do so we have to consider whether the miner being brought into close proximity to the coal when it is falling in the latter operation, does not run a greater risk of being injured by falls of coal, and also of roof if it happen to be bad. There is therefore in mining

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some evidence of what might be called a *co-relation of accidents*—that is to say, to avoid one kind of accident we may adopt means which will lead to increased risk in other directions; and it is evidently this consideration which induces experienced men to be so very cautious in making changes, and which has apparently led the Commissioners themselves to conclude, "that although there are many mines which can only be safely worked by the invariable use of safety lamps, yet the preponderance of accidents from falls, makes it desirable to employ naked lights wherever it is practicable."

The best seams have for commercial reasons been usually worked first, but it is generally assumed that the proper method is to work the seams in descending order. There is evidence of the fact, first noticed by Sir George Elliot long ago, that in some cases the working of an upper seam within twenty fathoms of a lower one hardens the coal in the lower and improves its roof; and there is also evidence that a lower seam being worked first, hardens the coal and roof of a seam lying from five to twenty fathoms above it—the Yorkshire men in this case say that the "surfeit is taken out of the coal,"—probably it is rendered less brittle by the gas being drawn off.

We have experience ourselves of the same interaction in our own coalfields—for example the working of the Pyotshaw coal over the Main coal in this locality, and of the Five-feet coal over the Splint in the Dunfermline district, produces in some cases this hardening or toughening of the lower seam, but whether this improves a bad roof or otherwise, is a point on which members of experience may have something to say.

The evidence taken shows considerable difference of opinion as to the proper method of timbering; many advocate the North of England deputy system; others again think the best protection is got by allowing the hewers to timber their own places, especially where the seams are thick and the roofs bad; and the Commissioners find themselves unable to say which system is best, or to lay down any general rule on the subject, but they think much could be done towards reducing accidents of this kind by attention to various points, the most novel of which appears to be the making a separate payment to miners for setting timber. There

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is much evidence that miners, getting a rate per ton for working the coal, are sometimes so unskilful as not to know where to erect timber; often so careless as to neglect to set it, although they know where it should be put; and always inclined to delay the securing of their working places for the purpose of getting out the mineral on which their pay depends. If the roof is bad, an extra payment per ton is made. The Commissioners in effect say:—Give the collier the usual rate per ton and make the extra payment depend on his securing the roof. Protect him against the temptation of making a little money by running some risk. Their suggestion seems to the point and worth your consideration.

Stress is also laid on driving the working places as rapidly as possible, by putting an ample number of workmen in each wall face, so as to expose the least number of men to danger at any one time. Less coal will be opened out for the same output; there will be fewer roads to keep, and the places will not be kept so long hanging on wood. But where there is a number of men in one place, is there not more noise and confusion, and will that not tend to prevent any working or settling of the roof being observed, and will not the men depend on one another? Whether what we have ventured to call the co-relation of accidents comes into play here is also a point which can only be profitably discussed by practical men.

The Commissioners indicate that coal cutting machines may contribute to a reduction of accidents of this kind, by reducing the time the men spend at the face exposed to risk of falls.

It is understood that the Mines Regulation Bill, recently introduced by the Home Secretary, was based on the Commissioners' report. It seeks to enact that where the timbering of the working places is done by the miners, suitable timber is to be provided at convenient places, and the distance between the props and also between the sprags or holing props, is not to exceed six feet.

SPONTANEOUS COMBUSTION.

The Commissioners say this frequently leads to fatal accidents. They have themselves made no experiments on the subject, and

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it rests where it was left by Abel and Percy in their report to the Royal Commission appointed to inquire into the Spontaneous Combustion of Coal in Ships.

In the evidence the opinion is always given that spontaneous combustion, when it arises in the small coal left in the waste, is due to the decomposition of pyrites; and, that when it occurs in pillars, it is caused by the heat set up by friction and slipping. The latter opinion seems to be based on the fact that when a crush is taking place in pillars, the temperature of the mine is considerably augmented, but we are not aware that any direct experiments have been made to ascertain the amount of caloric produced by the crushing of coal.

The presence of moisture promotes oxidation of pyrites by bringing the oxygen of the air into intimate contact with the surfaces of the oxidisable material. If the pyrites and coal be so covered that the heat as it is generated does not escape, it will burst into flame. But coal takes fire in which there is no pyrites, and which is perfectly dry, and there is at least one example in Scotland of spontaneous combustion taking place in a shaft pillar where there was no crushing; and coal has been known to ignite on the sides of main roads where the whole intake air was passing, and, consequently, the heat was in no way bottled up. So the oxidation of pyrites in the presence of moisture, and the heat caused by friction and crushing, do not account for spontaneous combustion in every case.

We are all largely acquainted with the development of heat by friction, and it is only natural that we should account for what we observe by causes with which we are familiar. But is there no other way in which the heating may be accounted for? Let us see. Here (Fig. 1) is an ordinary gas burner and a fine platinum wire. Let us twist this wire into a spiral form, so as to bring as much surface as possible into a small space; let us now heat the spiral slightly in the flame, then extinguish the flame, and allow the gas to play freely on the wire. We notice that the wire grows hotter and hotter until it becomes incandescent and re-ignites the gas. Here, then, we have a case of spontaneous combustion caused by the presence of a metal, not only incombustible but the most refractory substance known. How do we

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account for it? The noble metal platinum has the power in a superior degree of condensing certain gases on its surface, and in

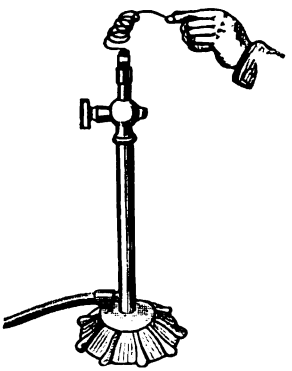

FIG. 1. — Experiment illustrating Catalytic Action.

this condensed state they are brought within the range of their chemical attraction and unite with evolution of heat, which accumulates in the wire to such an extent that it becomes hot enough to ignite the gas. The platinum itself undergoes no change; simply by its presence it enables the combination to take place, and when a body has this power it is said to exert a catalytic or contact action. Why is it called a catalytic action? The celebrated Swedish chemist, Berzelius, who investigated the subject, thought that this action was caused by a new force, which he termed Catalysis. There is reason to believe that this force was purely imaginary, and the phenomena, although they can be accounted for by actions with which we are more or less acquainted, are yet not well understood, and in using such a word as catalysis we are simply attempting to bury our ignorance beneath a sounding name.

We have thus fully considered this catalytic action because as we will see by and bye, it has an important application in fire-damp indicators, and will also come into notice when we discuss the action of incombustible dusts in determining the ignition of gas and air mixtures.

Carbon has a property somewhat akin to this action of platinum, having the power of condensing within its pores some-

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thing like nine times its volume of oxygen. This condensation is, of course, accompanied by the development of heat. We have then the development of heat and the establishment of oxidation taking place at the same time. If we have an open porous coal crushing, we have whatever heat is generated by friction; a large surface of small coal exposed, which occludes the oxygen of the air and causes heat by condensation; and the substance condensed is the oxidising material itself, which is thus brought into the most intimate connection with the carbon. We have the smallest of the crushed coal in the centre of the pillar with the larger masses thrown over on the outside in such a way as to keep in or bottle up the heat which is generated. There are, therefore, a great many forces all tending to the same result, which may ultimately start combustion by inflaming the finest dust, and this, without calling into play the action of pyrites and moisture, which are known to be often absent.

In this way the charcoal used in the manufacture of gunpowder has been frequently known to take fire.

The experiments of Richter have demonstrated that oxygen is absorbed by freshly gotten coal, with the evolution of carbonic acid and water, while part of the oxygen is fixed in it by the formation of some solid oxygenated body. Spontaneous oxidation of coal is thus established, and is at least *one* of the causes of the so-called spontaneous combustion in mines.

ACCIDENTS FROM EXPLOSIONS.

Closely connected with this is the subject of ventilation, and the Commissioners are satisfied that the main problem of producing a current has been solved, as furnaces are in existence in deep shafts circulating volumes of from 200,000 to 400,000 cubic feet per minute, and there are mechanical ventilators passing quantities of from 100,000 to 250,000 cubic feet per minute. Continental miners, who have not been able to circulate such quantities, have shown, as may be noticed in Mr Moore's Review, that from 25 to 50 per cent. of the air entering our mines is lost by leakage before reaching the working faces. The Commissioners, while recognising this, point out that, as long as a sufficient body of air for the dilution of gases issuing from the

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coal reaches the face, the leakage serves a useful purpose in preventing stagnation in the worked out parts of the mine.

Mechanical ventilators have often been injured and rendered useless by explosions, at a time when they were most needed, and the Commissioners suggest that the fan should be placed at a safe distance from the shaft, and the mouth of the upcast so slightly covered over that it will, in the event of an explosion, give way before injury is done to the machine. It will be observed that this is a provision in the Mining Bill recently introduced by Mr Childers.

The Commissioners lay stress on the continuous registration of the work of the fan, and point out that a second engine in reserve is a valuable adjunct.

Mr Moore and Mr Alexander give evidence that a greater number of explosions happen on the first two days of the week, and it is suggested that this may be due to the leaving of the ventilating furnace unattended during Sunday and temporary stoppages; and another provision introduced into the same Bill, is that ventilation is to be constantly produced at all times by day and by night throughout the year.

Systems of working doing away with doors, which are a constant source of peril, and the adoption of separate splits, especially for different seams, are recommended as practicable means for the localisation of explosions.

The subject of ascensional ventilation, imperative in Belgium, is discussed, but no recommendation is made; and the Commissioners also consider whether it is desirable to insist, as in Prussia, on a certain minimum quantity of air being supplied to every colliery, based either on the number of men employed, on the area of the workings, or on the amount of coal raised in a given time; but they think it doubtful whether such a standard of ventilation could be advantageously employed.

NOTE.—The Prussian regulations regard every mine in which fire-damp has been seen during the last two years as a fiery mine, in which there must be circulated 53 cubic feet per minute for every ton raised daily, and if this is insufficient to dilute the fire-damp till it forms only 1½ per cent. of the air it must be increased. The current may be reduced, however, if it is not contaminated to a greater extent than 1½ per cent., to 35 cubic feet per minute per ton raised daily; but in no case must it be less than 70 cubic feet per minute per workman employed underground

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The Commissioners are disposed to regard the facility for ventilation attending upon the longwall system as insuring the safest working where such system is applicable.

Fire-damp.—The analysis of fire-damp issuing from coal shows only slight variations in the composition of two blower gases used by the Commissioners in their experiments on safety lamps and coal dust.

	Garswood Hall.		Llwynypia.	
	From Holder.	From Pipe leading to Holder.	From Pipe from Holder.	From Pipe to Surface.
Carbonic Acid, .	0·86	0·86	0·49	0·27
Air, . . .	12·64	8·01	53·00	3·71
Nitrogen, . .	2·34	2·27	4·07	3·01
Marsh Gas, . .	84·16	88·86	42·44	93·01

It consists mostly of marsh gas, carbonic acid and nitrogen being present only in small proportions.

According to the law of transpiration, the gas which exudes first from the coal will contain a larger proportion of marsh gas than the portion which comes off at a later period. The latter will contain a higher percentage of carbonic acid and nitrogen. The following analysis by J. W. Thomas* of gas obtained by boring into the seam itself and gas exhausted from a lump of the same coal proves this:—

	Gas obtained by boring a hole into the seam.	Gas exhausted in vacuum from a lump of coal.
Carbonic Acid, ...	0·44	... 5·46
Marsh Gas, ...	96·54	... 84·22
Oxygen, ...	0·00	... 0·44
Nitrogen, ...	3·02	... 9·88
	100·00	100·00

Gas which collects in old workings and which makes its appearance in consequence of a diminution of atmospheric pressure, or from falls in the waste, will probably have a different composition from the blower gas; it will contain more carbonic acid and nitrogen, and it will also probably be affected by chemical

* Coal Mine Gases and Ventilation.

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changes going on in the goaf. Gas from old workings, too, will generally enter the mine diluted with a considerable quantity of air, and the various stages between a mixture containing 2½ per cent. of marsh gas, when a cap first appears distinctly on the flame, and an explosive mixture will be passed through so gradually that there is much more chance of the existence of a cap being observed, than in the case of a mixture with almost pure marsh gas from a blower or from freshly cut coal. In the latter case, the explosive mixture will be so rapidly attained that the presence of gas, as indicated by a cap on the flame, may escape notice altogether. Gas like the last which gives little indication of its presence by a cap is called "sharp" or "silver" gas. That used by the Commissioners at Garswood Hall Colliery was of this nature and a cap could only be attained by careful adjustment between the narrow limits of 2½ and 5 per cent. Reference to the analysis shows that this was almost pure marsh gas, while, on the other hand, that with which they experimented in South Wales contained a considerable quantity of air which had become mixed with it in entering their holder. With this gas they had no difficulty in observing changes on the cap produced by the addition of proportions of from 6 to 10 or 11 per cent. The gas from the strata was practically the same in the two collieries; but the difference in the amount of air with which it was diluted, made all the difference between the characteristics of sharp gas and the indications furnished by the kind of fire-damp more usually found in mines.

Ignition.—Sir Frederick Abel found, in his experiments at Garswood, that a current containing 3 per cent. of gas and travelling with a velocity of 100 feet per minute, produced an elongation of the naked flame of the Davy lamp; with 3¼ per cent. a fine flickering flame was observed which lengthened as the gas increased to 3½ per cent.; with 3¾ per cent. it became prolonged into a lambent flame which increased in size rapidly as gas was added up to 4½ per cent., when a general ignition of the mixture occurred.

With velocities of from 200 to 1000 feet per minute, currents containing 3½ per cent. of fire-damp were ignited, sometimes almost immediately, but occasionally not until the current had

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been passing the flame from 5 to 10 seconds. In two or three instances a gas mixture containing only 3 per cent. of fire-damp inflamed throughout, after the current had been passing some time. When discussing the action of dusts we will see to what this is attributed.

It appears then that a mixture of marsh gas and air which will produce an extremely faint cap, becomes by the addition of about 2½ per cent. of marsh gas converted into a mixture which will rapidly produce an explosion. The distance between the point of recognition and the point of peril is therefore very short indeed.

Escape of Gas from Coal.—Gas generally escapes from freshly cut coal quietly, but under conditions which have not been ascertained.

The pressure at which it may exist in the solid coal has been made the subject of many experiments. Mr Lindsay Wood, one of the Commissioners, experimented in the Northern Coalfield at depths varying from 125 to 211 fathoms. Holes were bored horizontally into the seam of different lengths up to 47 feet. The pressure of the gas exceeded 200 lbs. per square inch in many cases, and in one instance a pressure of 461 lbs. was registered.

With the view of gauging the pressure in another district, corresponding experiments were made in South Wales with the following results:—

Colliery.	Depth Fathoms.	Length of Borehole.	Pressure per Sq. Inch.	Cubic Feet of Gas per Hour.
Celynen, Abercarn,	176	42′ 0″	129	1·60
	247	47′ 10″	430	0·01
	250	20′ 3″	318	1·88
Harris Navigation,	355	30′ 0″	150	0·00
	361	26′ 9″	116	0·287
Merthyr Vale, . .	400	41′ 2″	170	3·66
	150	49′ 9″	280	0·002

There seems no well defined relation between depth and the pressure of the gas in the coal; nor yet between the pressure and the quantity of gas emitted. At any rate, the tension of the gas increases rapidly as the distance from the face increases; and this variation of pressure with the distance from the face probably remains constant for a considerable time, so that the discharge

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from a given area of face will also be constant for some time. For the purpose of determining what immediate effect ceasing to work the coal has on the amount of gas it throws into the air, the Commissioners had observations made at Boldon Colliery by Mr Liveing with his indicator. It was found that during an interval between Friday and Monday, of sixty hours, there was hardly any appreciable difference in the amount of gas produced. When the section experimented on was working it gave off 75 cubic feet of gas per minute, and on Sunday night it had fallen to 67 cubic feet per minute. Mr Liveing found in the same colliery that 74 cubic feet of gas were given off from a *working* face, while only 33 cubic feet were given off from a face of the same length which had been *standing* for twelve months.

The chief circumstances which seem capable of exerting any influence on the escape of gas from coal are variations of pressure due to the superimposed strata, and the effects of variation of pressure and temperature of the atmosphere.

Mr Hall, one of Her Majesty's Inspectors, bored holes into the face of the coal; into these he tamped iron tubes in which he could, by withdrawing a piston, create a partial vacuum on the face. He found that the gas followed the piston almost as fast as it was pulled out, and only in one instance did his gauge show the slightest vacuum.

The escape of gas from coal due to the diminution of pressure in the air of the mine has lately been tested, on a large scale, at Karwin, in Austrian Silesia, where a partial exhaustian of a whole pit has been tried. With the downcast closed air-tight and the fan going, a water gauge of 2·36 inches was produced, but in consequence of leakage from old workings the barometer only fell one-tenth of an inch below what it would have stood at had the downcast been open. The quantity of gas passing out of the mine was increased by 83 per cent. To get rid of the complication from the old workings a fresh trial was made on a section unconnected with any goaf, consisting only of an incline 208 yards long and an accompanying travelling road. The same reduction of pressure caused an increase of 40 per cent. in the output of gas. The shaft from which the leakage occurred was then closed, and a diminution of 0·15 inch in the barometer

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increased the quantity of gas to $2\frac{1}{3}$ times its previous amount. These seem extraordinary results, and the Commissioners find it difficult to reconcile the large increase of gas observed, with the fact that no equivalent increase was found when the barometer fell from natural causes, to the extent which had been artifically produced.

This diminution of pressure and consequent liberation of gas will be caused, as Mr Hall has pointed out, by a blown out shot in a narrow mine. If a second shot be fired (which emits flame) quickly after the first, it will probably ignite the gas liberated, and produce an explosion.

Sudden Outbursts.—These may come either from the coal itself or from the roof or floor.

Outbursts from the Coal.—The most remarkable outburst was that which occurred at L'Agrappe, near Mons, which forced its way against the air current, up the downcast shaft, and took fire in the engine house, and burnt as a column of flame from the mouth of the pit to the height of 120 feet for three hours.

The natural gas, which is estimated to be used to the extent of 28,000 cubic feet per minute in and around the city of Pittsburgh, and which is obtained from bores 200 fathoms deep, clearly shows that gas exists in the free state in the earth's crust.

Sudden outbursts in this country generally occur in soft coal. In one at Walker Colliery, it is recorded that on approaching a dyke a quantity of small coal, amounting to eleven tons, was violently projected into the workings, accompanied by a discharge of gas. In another, at Abercarne, a heading having passed through a hard portion of the seam, was approaching a region of softer coal, when a large mass was blown out and gas rushed into the workings with such force as to overthrow the men and tubs. It is estimated that it produced more than a million cubic feet of gas. Another occurred at Celynen whilst a roadway of nine feet wide was being driven. It took place so suddenly that one of the men working in the face was buried in the small coal, which to the extent of forty tons was projected into the drift. These soft, porous parts of the seam are magazines of gas clogged with small coal, and when the compact coal surrounding them is sufficiently thinned the pressure may burst it out, the gas

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carrying with it into the workings the small coal with which it is associated. Against irruptions of this kind no ventilation can cope, and the only preventive of disaster is efficient lamps and military discipline.

Outbursts from the Roof and Floor.—These, it is now known, result to a considerable extent from the method of working. Thin seams of coal, shale, or porous stone lying under and over the working supply the gas at the high pressures which we have seen it attains in the solid coal, whilst the redistribution of pressure consequent on the removal of the seam effects its liberation. It has been noticed that these outbursts take place very often after a "weight," the gas issuing from a definite crack in the floor, generally near to and parallel with the working face.

If a seam have a certain thickness of pliable roof, and above that a strong rock, as the coal is removed the pliable portion "sags," leaving an open space between itself and the rock, which, if only a few inches in depth, will form a receptacle for a dangerous accumulation of gas. This will be forced into the workings when a break in the rock takes place. The Commissioners state that they have reason to believe that some unexplained disasters have happened in this way. A condition of this kind is met either by very close packing or the introduction of a rise "gas drain" (as at Ebbw Vale), formed by increasing the height of the rise roadway to the bottom of the hard stone which forms the roof of the cavity.

The section (Fig. 2) shows clearly the method of forming this gas drain, and needs no description.

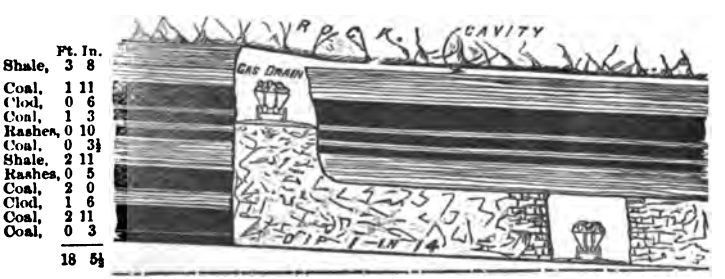

Fig. 2.—Section No. 15 Pit, Ebbw Vale.

In exactly the same way we may have cavities formed *under*

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the workings by the removal of the coal taking the pressure of the superincumbent strata off the pavement and throwing it on the face of the solid ; if there be a thin seam of coal, or porous strata of some kind, containing gas at high pressure, it will tend to liberate itself, and force up the floor, and when the weight of the cover re-settles on the packwalls and stowing, it will be compressed to an enormous degree and burst out at the point of least resistance, which is generally along the wall face. The formation of these cavities will depend on the elasticity and adherence of the strata, and easy partings will evidently favour their occurrence.

If a cavity have the same area as the workings above or below it, and be but $\frac{4}{10}$ths of an inch in height, it will contain sufficient gas, at the very moderate pressure of 300lbs. per square inch, to

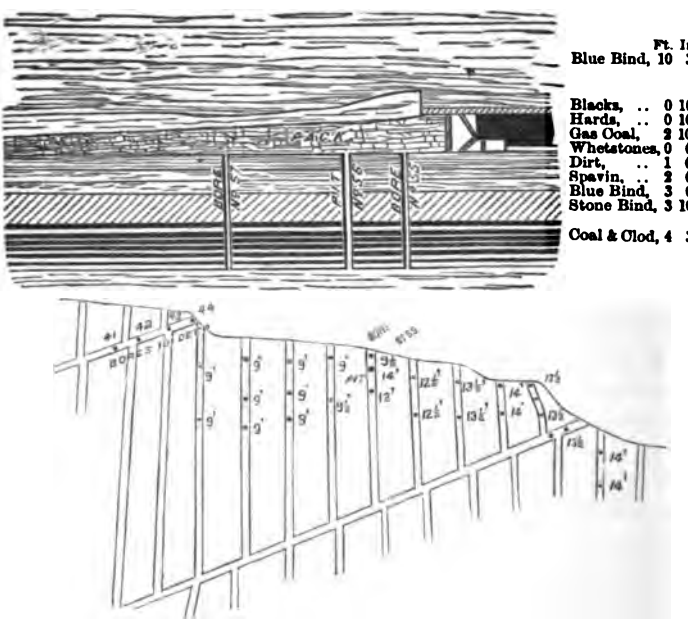
Ft. In.
Blue Bind, 10 3½
Blacks, .. 0 10
Hards, .. 0 10
Gas Coal, 2 10
Whetstones, 0 6
Dirt, .. 1 6
Spavin, .. 2 6
Blue Bind, 3 0
Stone Bind, 3 10
Coal & Clod, 4 3½
0 100 200 300 400 500 600 700 800 FEET.

FIG. 3.—Silkstone Colliery, Normanton.

bring the air in these workings to a highly explosive state, even supposing their height to be seven feet.

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If the gas bearing stratum be near the working, the gas will break through before it has attained any great pressure; but if more distant, and the separating rock be strong, then violent outbursts may occur which no ventilation can dilute. Gas has been known to come from strata 50 feet below the workings. When it occurs at shallower depths, it is often relieved by bores, of which Silkstone Colliery, Normanton, furnishes a good example. The seam there lies at a depth of 209 fathoms, and forms a working 4 feet 2 inches high. Below the seam, at a distance varying from 2 to 14 feet, lies an inferior coal split up by dirt partings. Bore holes are systematically put down to this seam, as the plan and section (Fig. 3) indicate, for the purpose of draining off the gas. They are put down 20 yards apart, and after a new hole is made nearer the face, the old one ceases to give off gas.

The evidence of the manager of the Oaks Colliery and others shows that the tendency to outbursts is considerably increased by working in large panels separated by pillars. The outbursts occur at the edge of the pillars when there is a sufficient area excavated for the pressure to again come on the floor and so force the gas out. At the Oaks it escapes into cavities from a stratum some 10 yards below the seam, in which bores have found a great deal of gas.

Special Methods for the Removal of Firedamp.—In Saxony the Commissioners aver that up to 1879 it was recognised by authority as a regular system to suspend open lights, called "eternal lamps," in the higher parts of the workings to burn away the gas. They notice the process of Herr Körner, of Freiberg, founded on the catalytic property of spongy platinum and palladium. With these metals he coated asbestos, and heating it over a petroleum lamp in rise workings got rid of the gas by slow combustion. Trials have shown that the effect was feeble or even nil. The Commissioners state that they have had still more visionary projects for the destruction of fire-damp submitted to their notice.

Atmospheric Conditions.—There can be no question that where gas is accumulated in old workings its dilatation, upon a reduction of atmospheric pressure, is liable to produce danger in a mine;

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but the gas will emerge before any fall in the mercurial barometer can be detected. The goaf forms a very delicate air barometer. In collieries where the ventilation is maintained by powerful agents the fluctuations of the barometer are of little importance, but those in which feeble currents are sustained by natural means must be very seriously affected by atmospheric changes.

To the suggestion that warnings should be issued by the Meteorological Office to colliery districts, the Commissioners give no countenance, as they do not think any benefit would result from them and consider that their dissemination would give rise to an exaggerated idea of their value and lead to a remission of watchfulness.

They find that the absence of general connection between colliery explosions and barometric changes is proved by the tables compiled by some of the Inspectors of mines, by the North of England Institute of Engineers, and by Mr Embleton.

A dangerous condition of a mine may be produced by a great variety of circumstances, of which probably atmospheric pressure is the one best understood and consequently least to be feared.

The Commissioners think that a very large proportion of accidents are due to the sudden intrusion of gas in such moderate quantity as to be undeserving the name of outburst, but nevertheless sufficent in the presence of coal dust, to be capable of giving rise to an explosion of the worst character.

They think it not impossible that earth shakes or tremors, which only delicate apparatus can reveal, may be a cause of the liberation of pent up gas, and that the observation of such tremors at stations distributed over the country might furnish useful information. Such a cause would, of course, account for the occurrence of a number of explosions close after one another at distant places.

In one case at least, the Commissioners say, it has been suggested that an explosion was caused by lightning descending a shaft, but they are silent as to whether gas may be ignited by sparks from a pick in hard stone, of which Mr Sawyer gives an instance in the transactions of the North of England Institute, Vol. XXXIII.

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FIRE-DAMP INDICATORS.

The Commissioners were instructed to inquire and report as to the adoption and efficient application of trustworthy indicators of the presence of fire-damp.

It seems probable from experiments that have been made that the smallest proportion of marsh gas which can be detected by

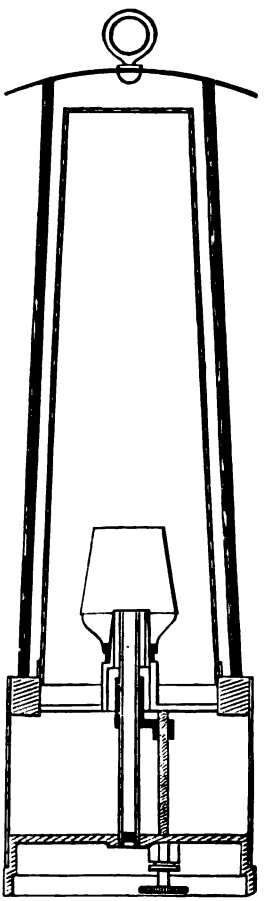

FIG. 4.—PIELER LAMP.

Transactions of the Manchester Geological Society, Vol. XVII.

means of a Davy lamp—the one generally used in the country, for

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examination of mines—is 2½ to 3 per cent. It has been proved that violent explosions may be produced when inflammable coal dust is thickly suspended in air containing about 2 per cent. of fire damp. The Davy lamp, therefore, does not in all cases afford evidence of the safety of a mine, and there is need for something capable of detecting the existence of smaller proportions of gas in the air.

The simplest method that has yet been proposed, and one to which miners will naturally have a liking, is the lamp of Herr Pieler. It is a large Davy constructed to consume alcohol with an argand burner, the tube supplying air to the centre of the flame passing vertically through the spirit vessel. A small converging chimney about one inch high surrounds the flame which is so regulated by a screw when in pure air, as not to appear above it. All the cap that is seen above the cone is therefore due to the gas. According to Pieler ¼ per cent. of gas gives a weakly luminous cap 1¼″ high; ½ per cent. produces a cap more sharply defined and 2″ in height; and with 1 per cent. the cone is 3½″ in height, sharply defined, and of an intense blue colour. The Commissioners placed one of these lamps in a current of 200 feet velocity containing one per cent. of coal gas, and shielding the flame with a glass cylinder, they got a steady cap in the middle of the gauze fully 6 inches long. This lamp was also tested by Mr Liveing in the return air at Boldon Colliery, where it was known that barely one per cent. of gas was present. It gave a cap fully three inches in length. The flame is easily extinguished and the Commissioners report that in an explosive atmosphere it would cause ignition in a few seconds. Enclosed in a case it would be less dangerous and its sensitiveness little, if at all, impaired.

Of instruments other than lamps which have been proposed for the indication of the presence of fire-damp two at least have been before this Institute. One by Mr Andrew Wilson* was a type of instruments depending on difference of buoyancy of pure air and mixtures of gas and air, and the other by Professor Forbes† founded on the resonance of air in a tube. The action of both of these types of instruments is

* Vol. II., Page 54. † Vol. I., Page 278.

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affected by density, depending on depth, temperature, the mixture of different gases, and the presence of aqueous vapour, so that they are manifestly inapplicable in mines.

Perhaps the indicator which has attracted most attention is Ansell's, and although it also is of no practical use underground, it is based on a principle of so much importance to mining people that it seems worth description. It is founded on what is known as Graham's law of the diffusion of gases, which states that they diffuse or intermix with one another at velocities inversely proportional to the square roots of their densities. That simply means that the lighter the gas the faster it diffuses. If, to fix our ideas by means of an experiment, we fill the tube (Fig. 5) with coal gas, the gas will diffuse through this porous plug of stucco faster than the air will diffuse into the tube. There will consequently be a diminution of pressure within the tube, as will be noticed by the rising of the water. The instrument takes different forms : the most portable is an aneroid barometer box enclosed in a case fitted with a porous back. When

FIG. 5.
Experiments illustrating Diffusion.

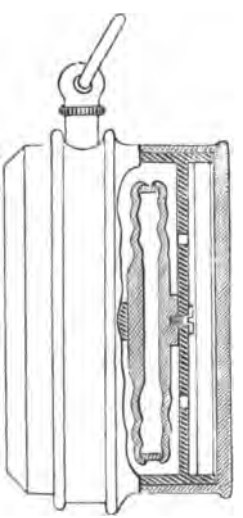

FIG. 6.—Ansell's Fire-Damp Indicator.
Ure's Dictionary of Arts.

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it is brought into gas the gas diffuses more rapidly into the instrument than the air diffuses out of it, so there is an increase of pressure on the barometer box, the index attached to which is graduated by trial for different percentages of gas. Instruments of this class are not only untrustworthy because they are affected by changes of density, but because they will only operate properly if at the beginning of a test they are filled with pure air.

Reliable and portable instruments have been devised by Coquillion and Maurice for estimating the quantity of fire-damp present in the atmosphere by effecting, by means of a heated platinum wire, its combustion in a closed vessel, and measuring the resulting contraction.

Coquillion's instrument consists of a graduated glass tube of small bore, having attached to one end a receiver of about one cubic inch capacity, across which a thin platinum wire is stretched between conductors fused into the glass. On the top of the receiver is a stop-cock. At the other end of the graduated tube

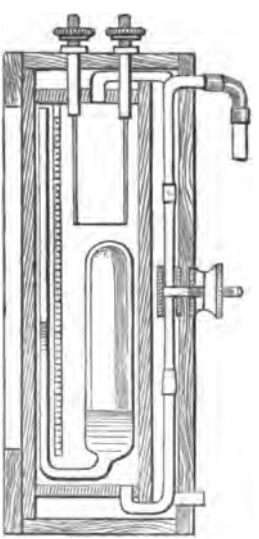

FIG. 7.—Maurice's Fire-Damp Indicator—one-third full size.
From the Transactions of the Chesterfield and Midland Counties Institute, Vol. XIV.

there is a pear-shaped rubber bag filled with water. When the

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stop-cock is opened and the bag pressed, the water is forced up into the receiver; upon leaving the bag free the water returns, drawing in after it the air to be tested. The stop-cock is closed and a current from a battery or magneto-electric machine is passed through the wire; the marsh gas is consumed; the pressure in the receiver diminishes; and consequently the water rises in the graduated tube which is marked by trial to indicate percentages.

In the instrument of Maurice the reservoir is $1\frac{3}{4}$" dia. and 7" high and the diminution of pressure due to the contraction after combustion is measured by the expansion of air enclosed in a bulb within the receiver. Here is a rough instrument which will give us a better idea of the instruments of Coquillion and Maurice.

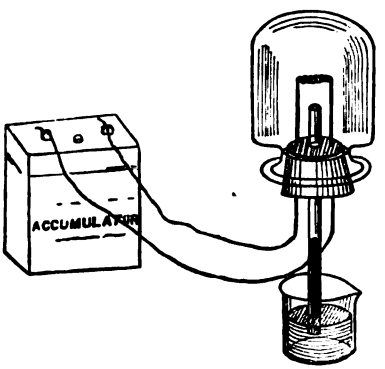

FIG. 8.—Experiment shewing the action of the instruments of Coquillion and Maurice.

The receiver is fitted with a rubber cork through which passes, air-tight, a glass tube of small diameter and two conductors, or electrodes, connected at the top by a spiral of platinum. When we connect the conductors to the accumulator it will be noticed that the current passing is sufficient to raise the platinum coil to a white heat. This increases the temperature of the air in the receiver and would force some of it out, but there is a rubber cork in the foot of the glass tube to prevent this. If we wait till the temperature falls and take out the cork it will be seen that the water does not rise in the tube. If we now take off the receiver and introduce into it the slightest quantity of coal gas—not too much or we will have an explosion—then pass the current for a second or

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two, so as to raise the coil to incandescence, allow the receiver to cool, and take out the rubber cork from the foot of the tube, we will find that the coloured water rises a considerable distance up the stem. By direct experiment it is easy to see how we could graduate this stem to indicate percentages of gas. Four volumes of oxygen combine with two of marsh gas to form carbonic acid and aqueous vapour. The aqueous vapour condenses and if the combustion is complete in place of the original six volumes there only remain two of carbonic acid.

In Liveing's instrument the brilliancy of the light emitted by a heated platinum wire, in an atmosphere containing fire-damp, is utilized. In a narrow box about eight inches long are fixed two spirals of fine platinum four inches apart. These have equal electrical resistances so that they are heated to the same temperature by the same current from a magneto-electric machine placed in the bottom of the box. One spiral is enclosed in a sealed tube of pure air, and the other is exposed to the atmosphere of the mine. The light from the spirals falls on each side of a wedge shaped screen placed between them. This screen is moved until its two faces are seen to be equally illuminated and its position on a scale, which has been marked by trial, indicates the proportion of gas.

Here is a box (Fig. 8) in which we have roughly fitted two plati-

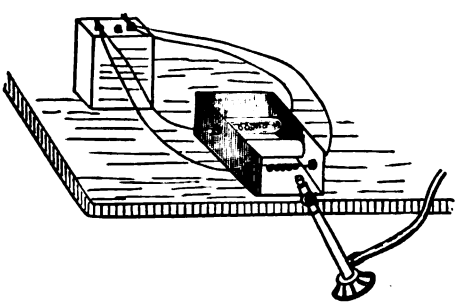

FIG. 9.—Experiment demonstrating the action of Liveing's Indicator.

num coils. One is sealed in a glass tube, the other is exposed to the air. The resistances of these coils are so arranged that the current

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from our accumulator is just sufficient to raise them both to what, in daylight appears to be a dull red heat. If now we direct a gas jet on the exposed spiral, you notice it, in comparison with the one in the tube, growing brighter and brighter until at last it attains so high a temperature as to ignite the jet. We can readily understand how by moving a screen between the coils along a line which has been graduated by actual trial, the percentage of gas in the air may be ascertained.

The Commissioners thoroughly examined this instrument and repeatedly tested it in known mixtures of marsh gas and air, and found that it gave very accurate determinations down to as low as $\frac{1}{4}$ per cent. of gas. The instruments of Coquillion and Maurice would require at least five minutes for each test, so that this one of Liveing's seems the only one applicable to the regular examination of a mine.

In the new Mines Bill it was provided that the Secretary of State should have power, where it appeared to him to be practicable and expedient, to require the daily or other inspection of any mine to be made with a gas indicator capable of detecting the presence of one per cent. of noxious gas, as well as with a locked safety lamp.

COAL DUST.

The part played by coal dust in colliery explosions has of late years attracted considerable attention. It seems unnecessary even to epitomize the history of its development further than to point out that the possibility of flame produced by explosions igniting coal dust was first suggested by Robert Bald, the acknowledged father of mining engineering in Scotland, as far back as 1828; that even before this, Buddle, the famous North Country viewer, noticed how the survivors most distant from the point of explosion were burned by the shower of "red hot sparks" of the ignited dust which it drove along; that the rôle played by dust was as clearly demonstrated by Faraday & Lyell in their report on the explosion at the Haswell Collieries in 1844 as it is at the present day; that the subject was in France re-investigated, in ignorance of Faraday's results, between 1855-75; and that from

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1875 onwards it has claimed the attention of Galloway and Marreco, and also of the North of England, and the Chesterfield and Derbyshire Institutes of Engineers.

Although Vital and Marreco had concluded that flame could be propagated with explosive effects by coal dust alone in the absence of fire-damp, the evidence given before the Commissioners by Her Majesty's Inspectors and others was to the effect that coal dust might aggravate explosions, but that they could not be originated or propagated by that means alone. Mr Hall, inspector of the North Wales District, however, gave evidence of the first practical experiment known. It was made in a brick arched mine, forty-five yards long and thirty feet area, driven from the surface. The flame from a 2½lb. shot, stemmed with small stones, only extended to fifteen feet; but when coal dust was scattered on deals (the pavement was wet) the whole length of the adit, on firing a similar shot, stemmed with small coal, the flame extended along the whole length of the mine, issuing in large volume from its mouth. The blast was so fierce that it would have been fatal to any one exposed to it.

Mr Galloway, in evidence, also expressed a strong belief that the most extensive of recent explosions were *largely* contributed to by coal dust.

There was so much difference of opinion that when the terrible calamity happened at Seaham in 1880, the then Home Secretary requested Sir F. Abel to make experiments with samples of dust collected from different parts of that mine.

These experiments were conducted with blower gas at Garswood Colliery, in a channel twenty-eight feet long, having a sectional area of about a square foot. Arrangements were made to secure uniformity in the velocity of the air currents, and also of the proper proportion and thorough diffusion of the gas in the air, and to keep the temperature of the currents similar to what would be found in collieries.

In a current having a velocity of one hundred feet per minute, Leycett (very inflammable) dust suspended in air containing 1½ per cent. of gas, produced a long flare as it passed the naked light, and after a short interval inflammation took place throughout the entire gallery.

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A series of comparative experiments with several different dusts was instituted to ascertain the proportion of firedamp which requires to be present in a dust-laden current, travelling at the rate of 600 feet per minute, in order to produce an explosion.

Dust from the Madeley and Leycett Collieries produced explosive mixtures with air containing only 2 per cent. of gas.

Samples of dust from Seaham, Blantyre, and Newport-Abercarn Collieries gave the same result when the current contained 2½ per cent. of gas.

These dusts were rich in coal and very fine, but one dust from Seaham, which chemical examination showed to be the poorest in coal (half of its weight being incombustible matter), and which was not so fine as the others, sufficed to produce an explosion with 2¾ per cent. of firedamp. The behaviour of this latter dust caused Abel to suspect that the ignition of the mixtures was not altogether due to the fact that the dust contained coal, but that the physical characters—the lightness, porosity, and state of division—of the dust had something to do with it. He, therefore, tried the effect of adding a fine, readily floating, *incombustible* dust —calcined magnesia—to the current, and found that with 2¾ per cent. of firedamp long flares of flame were produced within a few seconds of the mixture first passing the flame, and the inflammation speedily spread with feeble explosive effect. Other dusts were tried—kaolin, powdered flint, pumice stone, and slate dust—with similar results. With currents of 1000 feet velocity the effect of any one of these dusts being deposited in the gallery was to cause their instantaneous ignition if they contained 3 to 3½ per cent. of gas.

We saw when discussing the ignition of fire-damp that currents of high velocity containing no dust were not inflamed until after they had been passing the lamp flame for some time; and that, in the light of what we have just noticed, is probably ascribable to the fact of the current carrying particles of dust which have become accidentally suspended in it. These small dust particles, being instantaneously raised to incandescence, intensify the heat at the point and ignite the gas. The results also seem to favour

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the view that some dusts exert a contact—or catalytic—action similar to what we saw was possessed by platinum. When using magnesia it was noticed that a dark space intervened between the igniting flame and the flare produced by the ignition of the gas mixture, which seems to show that the dust particles, after passing through the flame, establish some oxidation of the fire-damp, the dust becoming more highly heated by the chemical action as it passes on, until at a *short distance from the flame* it becomes hot enough to ignite the gas and air mixture.

These experiments prove conclusively that a current containing dust in suspension may be explosive when the quantity of gas present is so small as to escape detection by a Davy lamp.

The next experiments were to determine whether coal dust would become ignited and convey or propagate flame in the *complete absence of fire-damp.*

With the view of imitating an explosion, a quantity of loose gun cotton, laid on the floor of the gallery, was electrically ignited and the length of flame noted (1st) when no dust was in the current, and (2nd) when dust was present. At velocities of two to three hundred feet the volume of flame was decidedly increased by the dust cloud, and the increase became more marked when the velocity of the current was raised to 1000 feet per minute. In the latter case in the gallery free from dust a flame of 15 feet was obtained, which increased to 18 feet with inflammable dusts. The dust had the effect of increasing the flame in the direction of the current and reducing it in the opposite direction, but there was an increase over all of 3 feet.

Numerous experiments were made to imitate the action of blown out shots, by firing small charges of powder from cannon into a current containing coal dust in suspension; but except that at the high velocity of 1000 feet per minute decided indications were obtained that dust particles were inflamed, giving an increase of the volume of flash produced, the experiments gave only negative indications.

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These results would seem to show that flame cannot be propagated to any great distance by coal dust alone.

Experiments were also instituted to ascertain the effect of blown out shots in igniting gas and air mixtures containing coal dust in suspension.

Cannon, when fired into air currents of 100 to 200 feet velocity containing $2\frac{1}{2}$ per cent. of fire-damp, and into a current of 300 feet velocity containing $3\frac{3}{4}$ per cent. of gas, produced no effect. But when discharged into a current containing only $1\frac{3}{4}$ per cent. of gas at a velocity of 100 feet, with coal dust thickly suspended in it, the portion of the gallery in front of the flash was filled with flame; with 2 to $2\frac{1}{4}$ per cent. of fire-damp, the gas and coal dust mixture fired with explosive effect.

In 1881 Mr Hall directed the attention of Sir F. Abel to the fact that one fatal and one serious accident had happened in his district, both occasioned by blown out shots. In both cases the sufferers had retired round a corner to places 100 feet distant. There were signs of charring on the props 6 feet beyond where the men had been, and although the shots contained only 1lb. of powder, there was a strong impression, among mining men on the spot, that the unaided powder flame (coal dust was known to be present) would produce the accidents. Sir F. Abel made some experiments on a large scale to ascertain to what distance the burning effect of a blown out shot would extend. They were made in the military galleries of Chatham fortifications, and the results we have collected into a table. They show how the flame is affected by the velocity of the current, by the quantity of the dust present, and by the dampness of the air; and prove that the accidents Mr Hall referred to could not have resulted from the powder flame alone, and were probably caused by the shots igniting the dust.

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Shot Lbs.	Length of Flame Feet.		
	Without Dust.	With Dust.	
2½ lbs., Tamped, . .	15	135	Mr Hall's mine experiment. Dust raised by shot.
1½ to 2 lbs. Tamped and Untamped,	20	37 to 45	Gallery, 8′ 8″ × 8′. Current from gun, 90′ per min.
1½ lbs., Untamped, . .	32 to 35	83, Tamped	Gallery, 5′ 9″ × 2′. Current with shot 131′ per min.
... ...	...	66	Current towards shot, 52′ per min. Air very dry.
... ...	...	26	Current towards shot, 94′ per min. Damp air.
3 lbs., Untamped, . .	...	70	Current, 55 feet per minute towards gun.

Experiments in gallery 81 feet long, intersected by another gallery at a distance of 70 feet from the gun. A current of 70 feet per minute passed from the gun into the left gallery. Charge, 3lbs. powder, untamped.

	Length of Flame Feet.		
	Main Gallery.	Left Gallery.	Right Gallery.
Slight quantity of dust,	50	0	0
Greater quantity, .	70	6	0
Still greater quantity, .	81	12	0
,, ,, .	81	18	3

In these experiments the dust was blown into the air, generally to the rear of the gun—not raised by the shots as in mines.

Sir Frederick Abel signed his report in March, 1881, and in 1882 Mallard and Le Chatelier, members of the French Commission, published the results of their inquiries into the part played by coal dust in colliery explosions, and severely criticised the methods of experiment and the results arrived at by Abel and Galloway. The French Commissioners set forth that in all explosions attributed to coal dust alone the absence of fire-damp

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could not be shown; that flame from a blown out shot was but little increased by the presence of the most inflammable dust; and that the only part coal dust could play would arise from the gas distilled from it by the heat of a fire-damp explosion, and this development of gas might not occur till after the actual accident, so that the effects of these gaseous products in increasing the force of the explosions might often be nil. They consider the readiness with which explosions are attributed to coal dust, to be due to the fact that both its existence and effects are visible: *before* an accident it is seen everywhere; *during* an accident the smoke resulting from its combustion is emitted from the pit's mouth and *after* an accident its coked product is found adhering to the timber. On the other hand fire-damp is invisible and leaves no distinctive trace of its existence. They point out that in lignite mines, where the dust is of the most inflammable description, no accidents have occurred because of the absence of fire-damp. Having stated their reasons for disagreeing with the conclusions of other investigators, they give their own views, and account for explosions chiefly by the fact that in actual practice less than 4 per cent of fire-damp cannot be detected by the Davy Lamp; that the difference between this and the 6¼ per cent. necessary to bring the air to the explosive point is so little that many causes, too numerous to mention, may raise the proportion of gas through this small margin, either by diminishing the volume of air or increasing the quantity of fire-damp.

It seemed necessary in view of these criticisms and differences of opinion, to inquire further into the effects of coal dust, and as the experiments of the Prussian Fire-damp Commission (some of which were witnessed by one of the British Commissioners) were conducted in a gallery approximating in magnitude to the working places of a colliery, they may be considered as decisive of the points disputed. They completely upset the views of Mallard and Le Chatelier.

These experiments were carried out in an elliptical main gallery 167 feet long, 5ft. 7in. high, and 3ft. 11in. wide. It was closed by a block of brick work at the shot end and open at the other, and it had an off-shoot gallery, 33 feet long, at right angles to it, at a distance of 93 feet from the closed end. Seven cast-iron

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cannon were built into the block, the centre one 1·57in. in dia., and 37in. long, and the others 1·38in. dia. and 31½in. long, and all pointed to a spot in the axis of the gallery, 16 feet in front of the brickwork.

Experiments were made to find the extra length given to a blown-out-shot flame by coal dust tamping.

Powder. Charge.	Length of Flame.	
	Clay Tamping.	Coal Dust Tamping. Medium Inflammability.
Oz.		
7·4	9′ 10″ to 13′ 0″	29′ 6″ to 52′ 6″
18	13′ 0″	62′ 0″

Experiments were made on the power of blown-out shots to raise and inflame dust. 1 lb. of dust per running foot was laid on the floor of the gallery for 33 feet from the shots. Charge, 7·4oz. of powder, fired from cannon near floor.

	Length of Flame.
Very Fine Dusts, ...	69 to 102 Feet.
Fine Dusts, ...	43 to 69 ,,
Medium Dusts, ...	39 to 49 ,,
Coarse Dusts, ...	20 to 39 ,,
Anthracite Dust (Dust Tamping), ...	26 to 30 ,,

With inflammable dusts, clay and coal-dust tamping gave the same results. With less inflammable dusts, however, the flame was considerably extended by coal-dust tamping.

While, with coarse dusts of low inflammability, the flame could not be got to reach beyond 39 feet, however far in advance the dust might be strewed, with two very fine and highly inflammable dusts the flame continually increased as the strewing was extended until, with 130 feet of the floor laid with them, the flame belched 16 feet outside the mouth of the gallery—that is, it had a total length of 183 feet.

Violent explosions resulted with either of these dusts when they

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were strewed in excess of 66 feet, and columns of flame from 3 to 6 feet in height, followed by dense black smoke, were projected from the vent holes of the gallery.

The influence of coal-dust on non-explosive mixtures of fire-damp and air.

These experiments completely corroborate the conclusions arrived at by Mr Galloway, and afterwards by Sir F. Abel.

Experiments were made on the elongation of a blown-out-shot flame, produced by coal-dust stemming when fired into gas mixtures.

The Commissioners quote results evidently taken from the following table.* The force of the explosion was measured by the distance a truck placed on rails at the mouth of the gallery was forced up an incline of 1 in 14.

Dust from the König Pit.			Dust from Neu-Iserlohn.		
Percentage of Gas.	Length of Flame. Feet.	Distance Tub blown along Railway. Feet.	Speed of Flame	Length of Flame. Feet.	Distance Tub blown along Railway. Feet.
0	45·9	2·29		49·2	2·60
1	49·2	2·95	One yard	62·3	3·93
2	52·5	3·28	per second.	78·7	4·92
3	65·6	4·10		95·1	7·21
4	82·0	7·60	Like lightning.	101·7	8·52
5	114·8	10·80	Explosion.	118·1	11·10
6	134·5	45·90		154·2	23 to 32·8 Tub much damaged.

It was also proved (1st) that a fire-damp mixture some distance from a blown-out shot could be fired by the flame transmitted by coal dust; (2nd) that an atmosphere in the main gallery, containing 7 per cent. of gas, ignited by a blown-out shot, exploded coal

* Trans. North of England Institute, Vol. XXXIV.

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dust in the cross gallery, although there was an intervening space of 56 feet altogether free from gas and coal dust; (3rd) that flame produced by the ignition of coal dust in the main gallery developed an explosion of coal dust in the side gallery, although there was an intervening space of 26 feet altogether free from coal dust.

Action of Dusts.—We have already discussed the probable action of incombustible dusts. Faraday, Vital, Marreco, and the Prussian Commissioners all attribute the action of coal dust to be due in part to the combustion of the dust itself, and also to the fact that gas is distilled from it by heat. The first portion of the dust acted upon by the flame of the shot yields gas which mixes with the air and is fired; this decomposes a further quantity of dust which is in its turn ignited, and so the explosion is propagated.

Secondary or back explosions have been noticed with dusts most favourable to the propagation of flame. They are due either to part of the gas developed from the dust by the first explosion remaining unburnt through deficiency of oxygen, or to gas being developed from dust within the highly heated space after the first inflammation. The inrush of air after the first explosion effects the combustion of such gases with explosive violence.

A calculation, founded on the volatile matter existing in the most inflammable dusts used in the Prussian experiments, and on that found in the coked product after an explosion, shews that if the whole of the dust were equally acted on by heat, 70 cubic feet of gas would be formed in the 33 feet of gallery which had been strewed—equal to 12 per cent. of its contents. A great part of the dust escapes the action of heat, but the figures afford an indication of how explosions may result in the complete absence of fire-damp.

To secure immunity from explosions when blasting, either (1st) the dust must be removed, or (2nd) rendered innocuous; or (3rd) means adopted for the prevention of blown-out shots; or (4th) the explosives or methods of using them must be so modified as to prevent the ejection of flame or sparks; or (5th) other methods substituted free from the dangers attending the use of explosives.

The Commissioners notice that the *removal of dust* is practised to some extent, but this can only be a palliative measure, because the still remaining dust will be raised by a shot. In the experi-

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ments which have been carried out, the effect of dampness in reducing the inflammability of dust has been often noticed, and although the Prussian Commissioners state that it requires to be saturated with two-thirds of its weight of water to render it harmless, Mr Galloway found that any dust used by him was affected by the slightest moisture in the air. If it be rendered sufficiently moist for a distance equal to the length the flame of a blown-out shot will extend, so that it cannot be raised by the current produced, there will be no danger of its ignition.

Its removal and the watering of the roadways and other parts of a mine will also reduce the augmentation and aggravation caused by its presence in a fire-damp explosion. The high temperature of mines and the speed of the air-currents cause the water to rapidly evaporate, and attempts have been made to lay the dust by means of hygroscopic substances—such as crude salt and a solution of calcium chloride. The proportion of crude salt found effective in preventing the dust from flying is stated to be nine tons per 500 yards of six feet roadway (about 20lbs. per square yard), applied once weekly for the first month, and once a month afterwards.

The Commissioners discuss some attempts that have been made for the *prevention of blown-out shots*, and have made experiments with Mr Stephen Humble's blasting plug, the only appliance that seemed to promise any prospect of success. They found that it does not reduce the occurrence of blown-out shots, and as the plugs were always destroyed when they were effectively used, they formed only an extravagant substitute for ordinary tamping.

The Commissioners were convinced that if shot-firing were abolished, or even if existing restrictions in regard to shot-firing were increased in stringency, a large number of collieries would require to be closed. Blasting seemed to be necessary, and they were so impressed with the dangers arising from it, when carried out in the ordinary way, that they have made a special study and investigation into the methods of so using explosives as to prevent the development of flame.

Attempts to produce explosives of analogous composition to gunpowder, that would not when fired emit flame, have resulted in failure. This may happen from the fact that gunpowder is not

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a definite chemical combination; it does not explode in the strict sense of the word, it simply deflagrates or burns with great rapidity.

Dr. M'Nab was the first to put into practice the idea of extinguishing powder flame by tamping over the shot a long cylinder filled with water, which, at the moment of explosion, would burst and quench the ignited gases. Experience has shewn that this method enables the workmen to enter their working places very soon after firing, in consequence of the powder gases being soluble in water, but it affords no certain security against ignition of an explosive atmosphere.

Suggestions have been made to employ, in connection with powder, solid substances, containing carbonic acid gas for example, which would be volatilised at the moment of explosion, so that the gaseous products would smother the flame. But the exposure to heat is too short to allow of any decomposition to take place, and the solid bodies are, to a great extent at least, scattered from the shot hole in an unchanged condition.

The Commissioners had experiments made by Mr Galloway on a mode of employing dynamite in connection with liquified carbonic acid gas. The firing of the shot shattered the reservoir containing the liquid, the dispersion of which, it was thought, would take place with sufficient rapidity to extinguish any incandescent sparks that might be thrown out. Of six of these cartridges which were fired in Bute Merthyr Colliery, four gave no indications of flame; but in two cases sparks were distinctly visible. The method could not be relied on for complete extinction of sparks, and as a much simpler and more economical plan of securing the same results, by porous water tamping, suggested itself to Mr Galloway, these experiments were no further pursued.

Nitro-glycerine has a proportion of oxygen in excess of that which is required for the complete combustion of the hydrogen and carbon which it contains, and its perfect metamorphosis should not result in the formation of flame; and probably this consideration induced the Commissioners to make experiments with explosives of which it forms the base. In the open-air it burns with a feeble flame, and when detonated a lightning-like flash is seen;

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used in a shot-hole it would probably give sparks by heating to incandescence dust or portions of the tamping. In the form of dynamite, that is when it has added to it about one-third of its weight of a porous non-combustible earth, its detonation causes sparks from the heating of particles of this porous material. The temperature of these sparks is sufficiently high to ignite an explosive mixture of gas and air.

Although high explosives, that is, explosives of the gun-cotton and nitro-glycerine class, are available for stone work, they are so rapid in action and exercise such a shattering effect as to be inapplicable, when used in the ordinary way, to the working of coal. Early in 1873, Mr Abel conceived the idea of distributing the greater force developed by the detonation of high explosives over a greater era by means of a column of water in which they might be exploded, and in this way so modifying their shattering action as to assimilate their disruptive effects to those of gunpowder. He foresaw that the water which distributed the force would also be available for the quenching of any sparks that might be produced if the shot happened to blow out. Trials carried out at Garswood with water cartridges on this principle shewed that the action of dynamite was entirely modified, and that the coal was brought down in large masses with the formation of very little dross, but sparks were, in a few cases, distinctly seen.

The results, however, were so encouraging that the Commissioners had special experiments carried out by Mr Galloway at Bute Dock, Cardiff. Shots were fired from a hole four feet deep in a heavy building of granite blocks, into an explosive gas mixture, which was contained in a canvas cube four feet square and four feet deep. This cube was provided with proper appliances for mixing the air and also for testing its composition.

The dynamite charge, fitted with detonator, was enclosed in a waterproof wrapping. The wires or fuse were placed for protection in the groove of a lath which passed through a bung. The charge thus fitted was inserted into a cylinder of sheet zinc or other material capable of holding water. The cylinder was then completely filled with water, and the bung, through which the wires passed, was forced $\frac{1}{2}$ inch into the mouth of the cylinder.

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This space of ½ inch was filled with plaster of Paris, and when it had set the charge was ready for insertion into the hole.

M'NAB SYSTEM.

Of 6 shots with powder, 6 to 8 oz., 24in. to 26in. water tamping, 4 fired gas.

ABEL SYSTEM.

Of 8 shots with powder, 3½ to 6 oz., 24in. to 30in. water cartridges, 6 fired gas.
Of 42 ,, dynamite, 3 to 4 oz., 24in. to 30in. water cartridges, 8 ,,

As 66 per cent. of the powder shots fired on the M'Nab system, and 75 per cent. of those fired in water cartridges ignited the gas mixture, while only 19 per cent. of the dynamite shots fired from water cartridges produced inflammation, it follows that although dynamite shots in water cartridges do not give absolute immunity from ignition of gas mixtures they would diminish in an important degree the risks attending blasting in mines.

These experiments were followed by others, also carried out by Mr Galloway, in the Bute Merthyr Colliery, in a seam 2½ feet thick. Thirty-three shots were fired altogether, with charges of from 4 to 11½ ounces of dynamite, enclosed in zinc water tubes, 1⅞ inches in dia., and from 2½ to 4 feet long. Generally they shew that the shattering effect of dynamite was so modified that the coal was fairly brought down, with charges equal to one-third the charge of powder that would have been required; but sparks were seen in the majority of cases, and even with the longest water tubes they were sometimes thrown out from 8 to 16 feet; only in one case was anything like flame seen. The Bute Dock experiments shewed that the dynamite water cartridge did not give absolute security when fired into an *explosive* atmosphere of gas and air, but that is a circumstance that cannot often occur; and the more important question remains, will these sparks, emitted by dynamite water cartridges, ignite an atmosphere containing a highly inflammable coal dust, or a mixture of gas and air which is inexplosive *per se* containing coal dust in suspension, which are obviously conditions of much more frequent occurrence?

Shots were fired from a steel block, having a hole 2 inches dia. and 19 inches deep, into a cube similar to what was used at Bute

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Dock. The coal dust employed was of an inflammable character. It was suspended upon sheets of paper over the shot, by which it was at the moment of firing blown into the air.

Shots.	Dynamite. Oz.		Dust.	% Gas.	
2,	2½,	No water or other tamping,	No dust,	No gas,	No flame.
1,	2½,	Enclosed in paper do. do.,	,,	,,	Flame, 1½ft. to 2ft.
4,	2½,	No water, no tamping,	1½ to 3½lbs.,	,,	Flame, 2ft. to 4ft.
4,	2½,	,, ,,	2lbs.,	1 to 1¾,	No flame.
4,	2½,	,, ,,	2lbs.,	1¾ to 6,	Explosion.
1,	2½,	24in. by 1¼in. water cartridge,	No dust.	5	No flame.
33.	2½,	18in. to 24in. ,,	2 to 3½lbs.,	5 to 7,	No flame.

These results demonstrate conclusively that dynamite water cartridges, upwards of 18 inches long, may be fired with security as blown-out shots in air containing as much as 6 per cent. of gas, and having an inflammable coal dust in suspension. Out of thirty-three shots fired in this way not one produced ignition. They also show that an atmosphere containing $1\frac{3}{4}$ per cent. of gas, with coal dust floating in it, is ignited by a dynamite shot fired without tamping.

It appears from a few experiments made by the Commissioners, and from the investigations of others, that gun cotton, tonite, and blasting gelatine may also be safely used in water cartridges, and that these high explosives may be confidently employed in conjunction with water *tamping*, that is, with a cylinder of water placed over the separately confined charge.

		Depth of Hole.		Dust.	% Gas.	
	Oz.	Ins.		Lbs.		
Blasting Gelatine,	2½,	12,	No water or tamping,	2,	1¾,	Dust ignited, flame 15 ft. high.
,,	2½,	18,	,,	2,	1¾,	Dust not ignited.
,,	2½,	18,	,,	2,	3½,	Violent explosion.
,,	2½,	36,	,,	2,	1¾,	Dust not ignited.
Gun Cotton,	3,	12,	,,	1,	1¾,	Dust not ignited.
,,	3,	10,	,,	2,	2,	Flame 20 ft. high.
,,	3,	12 to 14,	Water tamping,	2,	6½,	No flame.
Tonite,	4,	12,	No water or tamping,	2,	2,	Flame 30 ft. high.
,,	4,	12,	,,	2,	6,	Flame 20 ft. high.
,,	4,	12,	Water tamping,	2,	7,	No flame.

On the other hand, blasting powder cannot be used with

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inflammable dust in the air, or in a gas and air mixture which is in itself inexplosive, with any degree of safety, either in water cartridges or with water tamping. Out of 17 water cartridges eight inflamed an atmosphere containing dust and gas, and of four shots fired on M'Nab's system of water tamping, one ignited the mixture.

	Shots.	Oz.	Column of Water. In.		Dust. Lbs.	% Gas.	
Gunpowder,	2,	12,	..	Untamped,	No dust,	No gas,	Flame 8 to 10 ft. high.
,,	3,	12,	..	,,	1½ to 2,	,,	Great volume of flame.
,,	1,	12,	..	,,	2,	4,	Dust partly inflamed.
,,	3,	24 to 32,	12 to 18,	Water tamping,	2,	7,	Dust not inflamed.
,,	1,	40,	6,	,,	2,	6½,	Dust inflamed.
,,	3,	12,	8,	Water cartridge,	2,	4 to 7,	Large flame. Explosion.
,,	1,	12,	8,	,,	2,	2,	Dull explosion.
,,	2,	12,	4,	,,	2,	5 to 7,	Explosion.
,,	5,	8 to 12,	9 to 12,	,,	2.	6,	Dust not inflamed. Sparks projected.
,,	1,	16,	6,	,,	2,	6,	Explosion.
,,	2,	16,	6,	,,	2,	6,	Sparks projected.
,,	2,	24,	18,	,,	2,	7,	Dust not inflamed.
,,	1,	34,	9,	,,	3,	7,	Dust partly inflamed.

In these experiments with gunpowder it was noticed that there was a distinct interval between the explosion of the charge and that produced by the mixture of coal dust, gas, and air. It was also seen that the water in the cartridges was not in every case thoroughly dispersed, but that it was sometimes thrown out *en masse*, so that it did not produce its maximum effect in extinguishing the flame. Mr Galloway suggested that this might be prevented by distributing the water through a very porous body—moss, for example—so that if the shot blew out the liquid would be thoroughly dispersed in fine spray. A series of experiments were therefore made with moss and water tamping—the shots being fired into a nearly explosive mixture of coal gas having inflammable coal dust in suspension. The moss was kept soaking in water, and was placed loosely in the hole over the charge, so as to press out as little of the water as possible. With lengths of moss and water tamping of from 9 to 13 inches, and charges of from 2½ to 4 ounces of dynamite, the gas and dust mixture was

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in no case ignited. No sparks were seen in the shots fired during the day, but they were noticed in experiments conducted at night.

Shots.	Oz.		Lbs. Dust.	% Gas.	
1,	3,	No water or tamping,	2,	5,	Large volume of flame.
1,	2½,	,,	2,	6½,	Dust ignited.
1,	3½,	11 in. moss and water tamping,	2,	7,	Some sparks seen at night.
1,	3½,	10½ in. ,,	2,	7,	No flame nor sparks at night.
7,	2½ to 4.	9 to 13 in. moss and water tamping,	2,	7,	No flame nor sparks.
2,	3½,	Water cartridge,	2,	7,	Sparks seen. Ejected water dimly visible.

These trials of moss and water tamping gave such good results that a more rigorous test was instituted by firing the dynamite shots and shots of other high explosives so tamped, into a highly explosive mixture of gas and air. The length of tamping was reduced to as little as four inches without producing an explosion, and in no case either with dynamite, gun cotton, tonite, blasting gelatine, or gelatine dynamite, was the mixture of gas and air inflamed, but charges of 8 to 12 ounces of blasting powder, with 8½ to 10 inches of moss and water tamping produced explosions.

Powder,	2 shots,	8 to 12 oz.,	8½ to 10 in. moss tamping,	Gas mixture exploded.
Dynamite,	1 ,,	2½ oz.,	No tamping, ,,	exploded.
,,	9 ,,	2½ oz.,	4 to 13½ in. moss tamping, ,,	not inflamed.
,,	2 ,,	2½ oz.,	Water cartridge, ,,	,,
Gun Cotton,	3 ,,	3 oz.,	6 in. moss tamping, ,,	,,
Tonite,	2 ,,	2 oz,	6 in. ,, ,,	,,
Blasting Gelatine,	1 ,,	3 oz.,	5 in. ,, ,,	,,
Gelatine Dynamite,	8 ,,	2½ to 3 oz.,	5 to 6, ,, ,,	,,

The complete efficiency of this simple and cheap application of porous tamping in preventing the ignition of a highly-explosive atmosphere by blown-out dynamite shots is therefore demonstrated. It is a more secure method than the water cartridge, which, although equally efficacious in preventing the ignition of inexplosive mixtures of gas and air, containing inflammable coal dust in suspension, yet the Bute Dock series of experiments proved that dynamite in water cartridges ignited highly explosive gas mixtures in 19 per cent. of the shots fired into them.

Trials were next made underground with dynamite and other high explosives in water cartridges, and with the same explosives

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in conjunction with moss and water tamping, and it was found that although the shattering action is not so much modified by the application of porous tamping as it is by the use of water cartridges, still, with this simple stemming, their disintegrating effect is to a very great extent altered into the rending action exerted by blasting powder, and the force is still further distributed if the hole, when its direction permits, is filled with water before the moss is put in. Trials were made in the pit with ordinary tamping on the top of the moss and water, which proved that efficient work could be done in hard coal or stone by in this way preventing the loss of force consequent on the ready projection of the porous tamping.

Gun Cotton,	.. 3 oz.,	Gutskin water tamping,	No flame nor sparks.
,,	.. 3 oz ,	Water cartridge, 30 in. × 2 in.,	,,
Tonite,	.. 4 oz.,	Gutskin water tamping,	Shot blew; sparks projected 4 or 5 ft.
,,	.. 4 oz..	Water cartridge, 30 in. × 2,	Shot blew; no flame or sparks seen.
Dynamite,	3 shots, 3 to 4 oz.,	Water cartridge, 36 in.,	No flame or sparks.
,,	.. 3 oz.,	Moss and water tamping,	No flame or sparks.
,,	4 shots, 3½ oz.,	,,	Sparks seen in each case.
,,	.. 4 oz..	,,	No flame or sparks.
Gelatine Dynamite,	3 shots, 3 oz.,	Ordinary tamping.	Small coal made.
,,	1 shot, 3¾ oz.,	Water cartridge, 21 in., 15 in. moss over it.	Large blocks of coal produced.
,,	4 shots, 3 to 3¾ oz.,	Water cartridge, 18 in., another over it,	Results satisfactory; coal loosened.
,,	6 shots, 2½ to 3¾ oz.,	Moss and water, 30 to 33 in.,	Coal brought down in good lumps.
,,	5 shots, 2½ to 3¾ oz.,	Moss and water, 10 to 22 in., and over it 12 to 24 in. ordinary tamping,	Coal loosened and brought down in large masses.

Some violent explosives are not affected by immersion in water even for a considerable time. Nobel's blasting gelatine suffers least, but unless strongly confined, its detonation, the Commissioners say, cannot be relied on. Gelatine dynamite is readily detonated and suffers little from being placed in water, so that in conjunction with moss and supplemented by ordinary tamping, it is capable of doing any kind of work hitherto accomplished by gunpowder, with the inestimable advantage that it may be carried out with almost absolute safety in the most explosive and dangerous atmospheres.

In this connection it should be mentioned that in the bill

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recently introduced to Parliament it was provided that the main intake and return airways, and travelling roads, should be kept clear of dust or be well watered. That shots should not be fired until the dust in the vicinity had been removed, and the place watered, and, if gas was present, blasting was prohibited unless the explosive used would not ignite it. It was also provided that coal or coal dust should not be used for tamping. If gas had been found during the preceding three months, powder or other explosives were only to be used when all persons were out of the mine connected with the shaft on the same level, except those firing the shots, and those attending steam boilers, &c., not exceeding ten persons altogether. By the New Prussian Regulations only high explosives are allowed, and only if less than 3 per cent. of gas is present, and there must be a total absence of gas 12 yards from the shot hole before firing.

The security which the above methods of blasting affords will be diminished if the present mode of igniting shots by a lamp flame, or highly heated wire be continued, and the Commissioners recommend firing by electricity, which, apart from the absence of flame, removes all risk of premature firing, and in the case of a shot failing to go off it may be approached with safety.

Substitutes for explosive agents, mechanical appliances, compressed air cartridges, and lime cartridges are discussed in the report, but as most of these have already engaged the attention of this Institute, they need not be noticed. It should be stated, however, that the Commissioners had comparative trials made at Shipley Colliery in the bringing down of coal, which had been holed to a depth of three feet. Forty yards of wall face was allotted to each system, and, after 6¼ hours, the following quantities of coal had been brought down:—

	Tons.	Cwts.
By the Lime Cartridge Company	26	7
,, Mr Asquith's Wedge	15	10
,, Dingley & Acker's Wedge	10	11
,, Mr Hall's Wedge	9	12

In trials made in the ripping down of roof, Mr Asquith's wedge stood first.

Experiments were undertaken by the Commission for the pur-

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pose of determining whether the heat developed by lime cartridges would be sufficient to ignite paper, or the waste into which unslacked lime might be thrown. The temperature was found sufficient to melt tin but not lead (617° F.), consequently, lime has no power to ignite fire-damp. An attempt was also made to measure the pressure exerted by a lime charge, which, in 3 min. 25 sec., burst a cast iron tube $\frac{3}{8}$″ thick and 3″ inside diameter. It was found with the application of hydraulic pressure that it took from 42 to 44 cwts. per square inch to burst similar tubes.

The Commissioners are of opinion that the lime process could be substituted for blasting in some seams of coal, and they consider the immunity it gives from certain dangers always attending the application of explosives, is a strong incentive to its adoption.

LAMPS.

Lamps should be unable (1) under any circumstances likely to occur in mines to cause ignition of inflammable mixtures, even when passing at very high velocities; and (2) should yield a bright and steady light for a working day. They should be simple in construction, and not readily put out. If complicated there is a greater risk of their being imperfectly fitted together, and of defects passing unnoticed; and if easily extinguished a strong temptation is offered to the miner to provide himself with the means of obtaining a light. The readiness with which lamps show gas is of importance, and it is desirable when gas is indicated in dangerous proportion that the workmen should have the means of extinguishing all flame. Appliances for completely shutting up the lamp, if simple and reliable, the Commissioners regard of considerable consequence.

Lamps that best satisfy the first condition are, of course, those which are entirely independent of the surrounding air. The light in the lamp applied in connection with the Fleuss diving apparatus—which has been used for penetrating mines after explosions—is derived from the incandescence of a cylinder of lime heated in a spirit flame fed with pure oxygen, contained in a reservoir at considerable pressure. It is entirely unsuited for

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regular work underground because it is both complicated and heavy, and should only be used by skilled men. Electric lamps, connected by conductors to the dynamo, have been used to some extent about pit bottoms and in main roads, and attempts have also been made to use them at working faces; but to be practically employed for the ordinary work of the miner they must be portable and self-contained, and therefore independent of conducting wires. The Commissioners have examined several lamps of this class, some with primary and others with secondary batteries. The only one actuated by a primary battery that approached the necessary conditions was submitted by Mr Blumberg. It weighed 4½lbs., and was contained within dimensions measuring 6½″ × 3¾″ × 3¼″. At the beginning it gave a light of 0·92 of a candle, and after burning for 8 hours it had fallen to 0·22 of a candle. Others by Coad, Swan, and Pitkin ceased to give any light after 5½ hours. Of these lamps two gave sufficient light for 4 hours, and, as they only require the addition of the exciting fluid to put them in action, they form better lights than the lamps of Fleuss for exploring purposes. The best results, have, however, been got with secondary batteries by Mr Swan. Three of his lamps were tested. They weighed from 9 to 9½lbs., and measured 7½″ high by 4¼″ diameter. The best at starting yielded a light of 2·74 candles, and after 10 hours it was equivalent to 2·09 candles, and after burning 12 hours it gave ¾ths of a candle, or double the light of a Davy lamp. Stress has been laid on the fact that electric lamps give no indication of the condition of the air in a mine; but their batteries can evidently be easily used for the heating of platinum indicators, and it is stated that Mr Swan is presently engaged adapting a simple form of Liveing's instrument to his glow lamp.

Reverting to lamps fed with the air of the mine: When Davy invented his lamp probably the currents in mines seldom exceeded a velocity of 300 feet per minute. In such circumstances probably his lamp, and also the Clanny and Stephenson, were quite safe. Statistics collected for the Commission show that now the usual velocity in the working places is from 120 to 360, often rising to from 420 to 720 feet per minute (at Blantyre and Cadzow the greatest speed of air in working places is given at

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530 and 415 feet respectively) while in main airways currents of 600 to 2280 feet per minute are met with. In shafts, fan drifts, and dumb drifts current velocities are met with of from 1200 to 2000 feet per minute, and Mr Hewlett, of the Wigan Coal and Iron Co., gives the highest velocity in an airway at 3825, at a regulator, 5010, and in an upcast shaft, in which men descend with lighted lamps at 6030 feet per minute, equal to 68 mile per hour.

It had been demonstrated by others before the labours of the Commission began that at these high velocities the Davy, Clanny, and Stephenson lamps were all unsafe.

In most lamps when placed in an explosive current the wick flame is extinguished in a few seconds while the gas mixture continues to burn; in certain lamps the ignited gas was also extinguished in a short time. Such lamps would be absolutely safe, but this extinction of the gas flame did not hold with the same lamp for all velocities, and it was found by the Commissioners to be a condition that could not be insured. When gas burns in a lamp it should be shielded from the current, and it should be arranged to burn as far distant as possible from the glass so as not to crack it.

The Commission records about 2000 experiments made with over 250 different lamps; only the general results can therefore be noticed here. As far as possible experiments were made with two or three different lamps of the same kind so as not to hazard an opinion from the action of one.

They were tested in a wooden channel 20 feet long having a cross-section $13\frac{3}{4}'' \times 10''$. A current was produced in the box by a Körting blower passing steam at 60 lbs. pressure. The maximum current obtainable was 1,600 feet per minute. Observation of the behaviour of the lamp was made through a glass window in the box, on the top of which there were loose pieces to relieve explosions. By reducing the breadth of the channel from 10 to 4·6 inches, velocities of 3,500 per minute were produced. Gas was introduced into the air from a vertical pipe and measured by meter, and rigid tests were applied to ascertain that it was in the proper proportion and thoroughly diffused in the air. In some of the trials the lamps were inclined on a table and the behaviour of some of them was tested in oblique currents by directing the air on

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them by means of inclined screens or shields. By inserting a partition in the main channel, and causing the current to pass up a vertical conduit along a short horizontal channel and down into the main box again, it was possible to test the lamps both in ascending and descending currents.

All lamps were submitted to three tests—1st, in natural gas at Garswood Hall Colliery, near Wigan, in explosive currents containing 6¼ per cent. blower gas (= 5·46 marsh gas); 2nd, in natural gas at Llynypia Colliery, in the Rhondda Valley, in currents containing generally 12¼ to 13 per cent. mine gas (= 5·30 and 5.52 marsh gas); and 3rd, at Woolwich, in explosive currents containing 8 per cent of illuminating coal gas.

The Commissioners say the Scotch lamp can scarcely be regarded as a safety lamp at all. The one submitted to experiment was from Blantyre Colliery, gauze 7″ high and 2·9″ diameter, with a cone 2″ high and the gauze in it double through a height of 1¼″ from the apex. Tested at Garswood in a current of 400 feet velocity, containing 6¼ per cent. of natural gas (= 5·46 % marsh gas), it produced an explosion in 14 seconds. At Llynypia in a current of 600 feet velocity containing 6¼ per cent. of natural gas (= 2·65 % marsh gas); after 75 seconds it was red hot where the flame impinged but not elsewhere, and the experiment was stopped, an explosion not being imminent. Tried at Woolwich in a current of 1000 feet per minute containing 8 per cent. of coal gas it produced an explosion after three seconds, the lamp at once filling with inflamed gas.

In an explosive current of 400 feet velocity the ordinary Davy causes external explosions. The addition of a metal shield partly surrounding, or of a glass cylinder entirely surrounding the gauze (Jack Lamp) makes it safe in currents of from 600 to 800 feet per minute. When the glass of the Jack Lamp extends the whole height of the gauze (Davy in case) it resists currents having velocities of 1200 feet per minute. One of these only produced an explosion after being exposed for 47 seconds to a current of 3000 feet per minute. The Tin Can Davy (the lamp being enclosed in a tin can of its own height with a glass window) did not seem likely to give an explosion after having been exposed to a current of 3100 feet of velocity for two minutes.

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The Stephenson lamp becomes untrustworthy in velocities of 800 feet, and at 1000 feet per min. it almost always caused explosions. At high velocities the feed passed down the lamp and gas ignited at the top where the gauze speedily became red hot. As with the Davy there are many modifications of the Stephenson which make it more secure. The safest of these seems to be Gray's lamp in which the air feeding the flame is

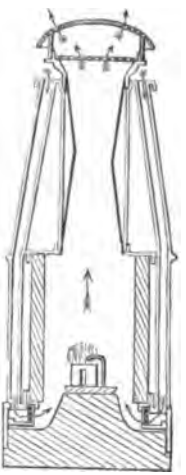

FIG. 10.—Gray's Lamp.

brought down from the top by four tubes. It gives a fair light, is not liable to extinction by considerable oscillations, and it resisted a current of 3000 feet per min. for 100 seconds when the glass cracked.

The Clanny fails in a current of 600 feet velocity. When the gauze is protected by an external metal case it becomes a bonnetted Clanny, which did not appear dangerous in currents of 1500 to 1900 feet per minute, but produced explosions at 2,857 feet velocity. When in addition to the bonnet the Clanny is provided with three gauzes close together at the bottom, but separated at the top, as proposed by Marsaut, the Commissioners have not been able to produce an explosion with it, although it has been for two minutes in a current of 3,100 feet velocity and

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seemed to be able to hold out so long as the glass remained

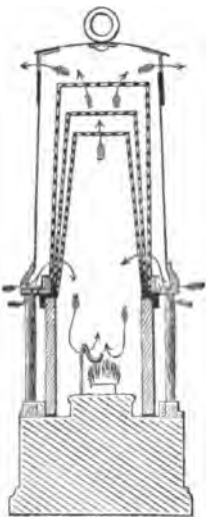

FIG. 11.—Marsaut Lamp.

intact. It gives a good light. Another lamp of the same type

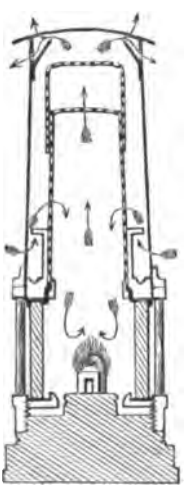

FIG. 12.—Evan Thomas Lamp.

is by Evan Thomas. The flame is bright and steady in strong

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currents, and it showed no signs of danger, after being exposed to an explosive current of 3,200 feet velocity for 8 minutes.

Dealing with the Muescler, the Commissioners notice that its security is considerably affected by the modifications it has undergone in this country with the view of rendering it less liable to extinction; they also point out its unsafeness in oblique currents, from the reversal of the action of the lamp, and the burning of the gas at the top of the chimney. This is impossible in the bonnetted Mueseler to which form of lamp Mr Stokes has added an arrangement by which the outlet is closed, and burning gas extinguished half a minute afterwards. Morgan's lamp, also a bonnetted Mueseler, the Commissioners consider one of the safest submitted to them.

Such current velocities as 3000 feet per minute, which several lamps have withstood, can only occur in mines at restricted parts of main airways, and in exceptional cases be caused for a short time only, by a blown-out shot or a heavy fall; hence the Commissioners conclude that lamps are now in existence which when properly used afford security under all circumstances likely to occur in mines.

The four in which the qualities of safety, simplicity, and good light are united are:—

	Weight Lbs.	Light. Candles.	Velocity Tested. Ft. per min.	Duration of Experiment.
Gray's,...	2¾	0·3 to 0·4	3·100	1 min.
Marsaut, ...	2¾	0·4 to 0·5	3·100	2 min.
Evan Thomas, ...	3¼	0·4 to 0·5	3·200	7 min. 40 sec.
Bonneted Mueseler, ...	2¾	0·3 to 0·4	2·850	

In the first three the flame is not readily extinguished but the fourth, like all Mueselers, requires careful handling.

The ultimate source of danger with all these lamps is the breaking of the glass, and the Commissioners suggest certain modifications for diminishing this risk, and see no difficulty in adding appliances for closing the outlets and inlets, and go on to

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consider arrangements that have been proposed for securing automatic "shut offs," when a certain temperature has been attained.

They consider it absolutely necessary that the safer and more complicated lamps should be regularly tested in an explosive mixture before being used.

Treating of *illuminants*, they comment very severely on the introduction of petroleum spirit, under the name of colzalene, without prescribing proper directions for the use of such a dangerous oil. Young's lamp, burning solid paraffin, yields a safe and good light, but the Commissioners consider the fact that the paraffin requires to be melted around the wick before the lamp will burn, a formidable obstacle to its use.

They conclude from experiments which they have made that for safety lamps seal oil is superior to rape oil, and find that a mixture, containing one part of paraffin or petroleum (flashing point not less than 80° F.) and two parts of rape or seal oil is a much superior illuminating agent.

The following provisions, relating to lighting, were included in the "Coal Mines Regulation Bill, 1886":—

In mines where safety lamps require to be used lamp stations for lighting or re-lighting shall not be placed in the returns. In any seam of a mine, where inflammable gas has been seen within the preceding three months, no lamp other than a locked safety lamp is to be used, and safety lamps only shall be employed in any working place or travelling road where derangement of the ventilation would probably be attended with danger by reason of an accumulation of inflammable gas; and the same rule applies to every working approaching a place where there is likely to be an accumulation of fire-damp.

Safety lamps are to be so constructed as to be safe in currents moving with a velocity of 800 feet per minute; and if Davy lamps are used, the protecting shield, but not the gauze, may be temporarily removed by a competent person, appointed in writing, in order to test for gas or to light shots.

The Home Secretary was empowered to prohibit the use of any safety lamp not provided with a shut-off apparatus for the extinction of the lamp flame or that of the ignited gas, and he

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also took powers to secure that the locking apparatus should be approved of by him, and could require that all lamps should be tested before use in an explosive mixture.

To anyone who attentively follows the work of the Commissioners there looms up a more or less distinct outline of the present position of the outposts of our mining battle—a battle in which we lose a thousand men a year. Mining is an art: an art consists in the application of knowledge to the purposes of life. This application constitutes engineering in its proper sense, but we cannot apply until we know. The Commissioners have applied their scientific knowledge with indomitable pertinacity, for the purpose of reducing the risks attending shot firing; and it must be admitted that in this direction they have advanced our line. The methods of dealing with fire-damp indicate a long advance from the time when quaint chroniclers tell us "a man more purposeful than the rest" descended the mine and burnt it out with a light at the end of a pole; but on the oversman, the man "more purposeful than the rest," the safety of our mines still in a considerable degree depends, and it is hoped that these notes may afford him useful information.

The PRESIDENT, in announcing the adjournment of the discussion of the paper till next meeting, complimented the author on his very scientific and able paper.

The following paper on "A Gauzeless Safety Lamp" was then read by Mr JAMES M'KINLESS:—

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ON A GAUZELESS SAFETY LAMP.

By James M'Kinless.

A careful perusal of the "Report of the Royal Commission on Accidents in Mines" must impress the reader with the fact that, notwithstanding the large number of lamps submitted to them, not one reaches the standard of absolute safety.

In page 68 of their Report they say:—If a lamp has the "property that, when placed in a current of an explosive "mixture, the flame and the internal ignited gas are both certainly "extinguished in a few seconds, such a lamp must be absolutely "safe, but it does not follow that a lamp is unsafe if the gas "continues to burn within the lamp."

That no lamp submitted to them fulfils this important condition will be perceived on reference to the published tests, which shew conclusively that, under certain conditions, the best of them will continue to burn in gas for an indefinite time.

It should also be borne in mind that in these experiments the gauzes were new, and consequently would offer a greater resistance to the passage of flame than after being some time in use—because oxidation takes place, and every time the oxide is removed by brushing, some parts of the wire of which the gauze is woven will become slightly thinner. The difficulty, therefore, is to determine where safety ends and danger begins, as it is very natural that people will get as much wear out of them as possible, and so long as the mesh appears to be perfect they are likely to be passed as safe. This consideration, coupled with the fact that a very small defect either in the mesh or the fitting parts of a gauze renders a lamp unsafe, convinced me that under certain conditions to be met with in a mine gauze is unreliable, and resulted in the production of a lamp from which it is entirely discarded.

This lamp I have now the pleasure of bringing under your notice (see Plate XVII.) The feed air is admitted above the glass and middle ring of the lamp, through very small holes, three times the length of their diameter, drilled in a belt or band which forms the base of a cylindrical chimney, and passes thence

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between this belt or band and the lower portion of an inner conical chimney down to the flame. On the outside of the inlet holes and inside the outer bonnet or shield, a short tube is attached to the middle ring of the lamp, with a flange at the top turned inwards, and the air enters the annular space thus formed through a number of holes of about $\frac{3}{16}$ths of an inch diameter, immediately below the flange, but higher than the small inlet holes, which are thus protected from the force of a strong current.

The results of combustion pass through the inner conical chimney—on the top of which is a cap or hood to catch the unconsumed particles of carbon or soot—and then escapes through very small holes, also three times the length of their diameter, drilled in a cap which fits the top of the cylindrical chimney.

A theory has been expressed with regard to safety lamps that only sufficient air should be admitted to support combustion, and the outlet should be large, so as to give the results of combustion a free escape. But in the lamp now before you that theory is reversed. It has a very large inlet, numbering 800 holes, whereas the outlet holes are limited to half the number. This arrangement secures the utmost illuminating power by supplying abundance of oxygen, makes ample allowance for choking up in dusty workings, and when the lamp is placed in gas it admits a large quantity, which immediately ignites and produces an excess of carbonic acid gas, for which there is not sufficient outlet, and the flame is at once extinguished. In low velocities of an explosive mixture the internal ignited gas will continue to burn for a few seconds, but increased velocity hastens the extinction, and in high velocities it goes out immediately.

The cap containing the outlet holes passes partly through an upper ring or diaphragm, which holds the parts securely in position and prevents the results of combustion from falling down inside the bonnet or shield and re-entering the lamp. In some lamps the burnt gases resulting from interior explosion are in part momentarily retained by the outer bonnet, and the inventors consider it an advantage, as tending to assist in the extinction of the flame by mixing with the feed air. This lamp, however, does

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not require any such assistance in gas, and, in my opinion, it must affect the lighting power of the lamp in ordinary conditions to some extent.

Robert Winstanley, Esq., mining engineer, of Manchester, said, at a meeting of the Manchester Geological Society—"Having "charge of a colliery, at which an underground fire and explosion "occurred in 1884 (the Limehurst Colliery, Ashton-under-Lyne), "I have had many opportunities of testing this lamp under all "conditions. In order to put out the fire, the mine had to be "flooded with water, and the re-opening has been a hazardous "operation; large accumulations and outbursts of gas have had "to be contended with, and under no condition has the lamp "failed, it being extinguished immediately on coming in contact "with gas. The lamp has been tested by C. E. Rhodes, Esq., the "manager of Aldwarke Main and Car House Collieries, Rother-"ham, at his lamp testing apparatus, and he reported that it stood "better tests than any lamp previously tried, as at the highest "velocities obtainable it went out immediately, the result being "the same in uphill, downhill, and horizontal currents."

It is much to be regretted that this lamp was not perfected until too late for the Royal Commission, as it not only fulfils the important condition which they consider gives absolute safety, but it appears to comply with every other condition they lay down as essential to a safety lamp, except that it has not an appliance to shut off the feed-air when in gas, but as it cannot continue to burn in gas, such an appliance is unnecessary.

It gives a good light which is not easily put out. It burns with a full flame at an angle of twenty-five degrees to the vertical and does not go out at thirty-five degrees. It will stand a rapid up and down movement, and even considerable jerking. The inner conical chimney is similar to the Mueseler, but being wider at the base, it is not nearly so sensitive, and will bear considerably more canting to one side before going out, though not sufficient to allow the flame to impinge on the glass long enough to break it.

It will indicate the presence of gas in small quantities. It is simple in construction (having few parts, which can be rapidly put together), and admits of much easier inspection than probably any other lamp known; it is only necessary to examine the lead

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plug (which is the system of locking approved by the Royal Commission), because with the base of the conical chimney and the cap containing the outlet holes in view, there can be no doubt about any of the parts inside the bonnet.

It is a very useful size, strong, and durable, and weighs exactly 3lbs. without oil. The oil vessel holds enough for two long shifts, and, except in dusty workings, it will not require cleaning more frequently. It has been in use by colliers in a dusty mine for shifts of eight hours without inconvenience, and I have had a lamp burning in a room upwards of sixty hours without showing any signs of choking, and it would probably burn another sixty hours before it required cleaning.

It has been stated by an opponent, that these small holes will choke up and be difficult to clean, but a moment's reflection will dispel any such fears, as, when it is explained that the holes are barely an eighth of an inch long, it will be evident that by knocking with a hard or wire brush they can be cleaned both easily and quickly, and this has been proved in practice.

It will be apparent to any one that the first cost of this lamp will exceed that of some modern lamps, though, with the aid of special machinery, the price has been brought down to 10s 6d each, delivered free to any part of Great Britain; and when it is considered that there are no gauzes requiring renewal, and the saving of time effected in cleaning, putting together, and inspection, these facts will tend to make it a very cheap lamp.

By using a special wick which has been made for this lamp and the compound illuminant recommended by the Royal Commission, excellent results are obtaimed at a cost not exceeding a penny per lamp per week, and as arrangements have been made to let the lamp out on hire at a penny per lamp per week, there can be no question on the score of economy.

A large number of firms have given sample orders to try it in the districts where it has been shewn (some of whom are already adopting it), and from the evident favour with which it is received, I am led to hope it will eventually come into general use.

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DISCUSSION.

The PRESIDENT asked what kind of oil was used.

Mr M'KINLESS said it was the compound recommended by the Royal Commission, and consisted of two-thirds of colza or seal to one-third of petroleum.

The PRESIDENT said he thought one of the chief advantages of the lamp was that there was no gauze. It would save trouble in keeping the lamp in repair.

Mr ROBERT BEITH, speaking from experience of the lamp, said it gave a good light, but got rather hotter than the Protector. They had tested it at Greenfield, and it was not so sensitive in gas as the Protector. The Protector went out in an instant This one took a few seconds more, still it went out. He asked how often the lamp had to be trimmed in working a shift of ten hours.

Mr M'KINLESS said he could hardly answer the question.

The PRESIDENT—You could burn spirit?

Mr M'KINLESS—Of course.

The PRESIDENT said that spirit might have objections, but it was certainly a very great convenience besides its cheapness.

The PRESIDENT adjourned the discussion; and on his motion a hearty vote of thanks was accorded to the author.

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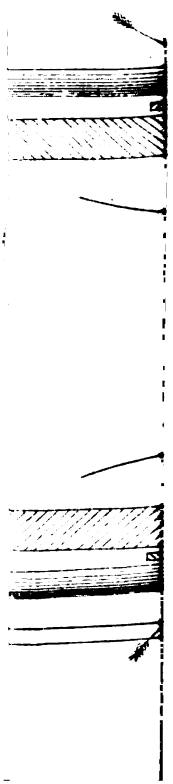

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THE MINING INSTITUTE OF SCOTLAND.

SUMMER MEETING—19th AUGUST, 1886.

THE members, to the number of sixty, travelled by special train from Queen Street Station, Glasgow, to Burnhouse Siding, near Grahamston Station, Falkirk, whence their carriages were conveyed by the Carron Coy.'s private engine to the works, which were reached about eleven o'clock. Mr David Cowan, the manager, having been summoned as a juryman, at this stage was temporarily absent, and the excursionists were received by his assistant, Mr James A. Tweedie, who, with the heads of departments—Mr D. A. W. Robertson, blast furnace manager; Mr John Ronald, pig iron agent; and Mr James Clelland, manager for collieries—at once conducted the visitors over the works.

Within the last ten years these works have been entirely remodelled and rebuilt. The alterations were commenced in 1873 by the former manager, Mr Gordon, and taken up and brought to their present stage of completion by Mr Cowan on his succeeding to the management in 1879. In the interval, the old buildings, many of which had done service since the institution of the works, have been demolished, only two now remaining as traces of the past. The new structures, which are of brick, are in the form of a rectangle, and the entire works cover an area of about thirty acres. The workshops are lofty, commodious, and airy. In the course of the remodelling operations, every effort has been put forth to secure the most advanced machinery, with the result that in nearly every section distinctive features are noticeable. The blast furnaces have the celebrity of being the first in Scotland

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that were fired with Cowper's Regenerative Stoves, which heat up the blast to a temperature of 1500 degrees. In the blast furnaces alone coal is used as fuel, the remaining section—the furnaces, etc., in the low or light foundry, the high or heavy foundry, and the brick works—burning nothing but the waste gases from the blast furnaces. These are collected in the usual way by covering their tops and leading the gases through down-comer pipes into a horizontal main, and thence through the works, the length of the gas mains being 2700 feet. Another feature is the arrangement of the hydraulic power by which it is utilised in the entire works, the pumps being placed at one corner and a system of piping carried throughout the whole. There are two sets of pumps working high and low pressure water, one consequence of which is that the machinery can be put in operation for fire-extinguishing purposes. This was admirably illustrated in the great square in presence of the visitors. Hydrants being distributed over the works, a regularly organised fire brigade was set to work, and in a few seconds had the hose in full play. An additional fact may be mentioned in connection with the new equipment, viz., that in the heavy foundry, castings up to 30 tons can now be produced. Fully two hours having been occupied in perambulating the various sections, during which the raw material was seen in the course of formation into pig iron, and that again into finished goods in the shape of grates, ranges, pots, rhone pipes, and a multitude of household articles, the members about half-past one congregated inside the Board Room, where the owners had considerately provided cake and wine, and where they were welcomed in name of the Carron Company by Mr Cowan, who apologised for the absence of his colleague, the Secretary and chief partner in the concern, Mr T. D. Brodie. He afterwards gave the toast of "The Mining Institute of Scotland," coupled with the President (Mr J. S. Dixon), which was heartily pledged. The President, in response said he was sure one and all would leave with the impression that this had been the most successful summer trip they ever had. (Cheers.) The Carron Iron Works were not exactly the first in Scotland, but he believed they were the first to be established in what they called the coal and iron producing districts. (Cheers.) Till lately, he under-

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stood, it had been a very old-fashioned work, but it had renewed its youth like the eagles. (Cheers.) This had been done under the able management of their friend, Mr Cowan—(cheers)—to whom and the Carron Company he asked them to accord their acknowledgments for their great kindness that day. (Renewed cheers.) Mr James Smart, vice-president, proposed "The Staff of conductors," coupled with the name of Mr Tweedie, who suitably replied. The company then separated, and in the course of half-an-hour re-entered the railway carriages, and were taken on to Grahamston Station, from which they walked to the Crown Hotel, Falkirk, where dinner was served, the table being profusely decorated with flowers from the garden of Mr Brodie of the Carron Company.

After dinner, the PRESIDENT said they might improve the time for a few minutes by having a word from Mr Laurence Hill, descriptive of what they had seen that day, and after that, Mr Cowan might perhaps supplement the description by going over the ground they had traversed, and giving them information regarding the works which they could not be expected to pick up on their visit.

Mr LAURENCE HILL said, although he had seen a great many works in many different places, he thought Carron Works would bear comparison with any of them—(cheers)—and the management certainly would. (Renewed cheers.) Nearly half a century ago, when he was quite a young fellow, he heard of the works, and that they were the oldest ironworks and the first ironworks in Scotland, and as he knew a good many of the works in the Coatbridge district,—Gartsherrie among the rest,—he wanted to see this one also. He went, and like the national poet, Burns, the door was shut in his face. He did not know the reason; but when, a year or two afterwards, he was asked to go and see the works with some people who were visiting in the neighbourhood, he of course went, and he had to confess that he never saw a more neglected, forlorn place. Indeed, he considered there was no wonder they did not like to let anybody in who had seen anything of ironworks. (Laughter and cheers.) The comparison between past and present, he was happy to say, was of a most diametrically opposite kind to his experience of fifty years ago.

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(Cheers.) He did not know who were the principals of the concern, but he had the pleasure of knowing Mr Cowan—(cheers)—and he need not say anything in his favour as to the splendid way in which he, in the comparatively short time he had had charge, had wrought the great changes they had seen that day. (Cheers.) They had to bear in mind the variety of the work. It was easy to work improvements if they had to turn their attention to one thing only. If they built a ship or a machine always of the same pattern, they easily got perfection, for their labour and attention were concentrated. But at Carron there were a dozen different things, and they were all carried on in the best possible style. (Cheers). He did not know whether they made Carronades still; but certainly they put out goblets, grates, and all other household and useful articles in the most beautiful styles possible. (Cheers.) Then, he thought the operations by which the waste gases were utilized showed good management. Not only were these gases used for heating the blast and raising steam, but they were used for drying moulds and for drying and burning bricks. (Cheers.) "Gather up the waste" was a capital motto for a manager, and he did not think it could be better done than they had seen it that day. (Cheers.) As one illustration of this, he might mention that he was looking at the slag before seeing the blast from the heater go off, and overheard an observation that it was a capital work this, but that they should run the slag into an iron waggon and save the trouble of lifting it. Well, he thought this was quite true; but, observing that the slags were being run into small lumps, he said to one of the men, "Why don't you use this?" "Oh," said he, "we used to use it, but now we sell the slag." (Laughter and cheers.) He was happy to say he had been there, and had enjoyed himself very much, and he thought they were all indebted to their friend Mr Cowan for what they had seen and learned that day. (Cheers.)

Mr COWAN, who was greeted with cheers, said he did not know exactly what he had got to do or say on this occasion. The President had asked him to describe or give a few of the details regarding what they had seen that day, but whether it was from his minute acquaintance with the details or otherwise, he

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had got very little to say. Taking their programme, he noticed they had commenced at the brick-work. Well, perhaps that was the best place at which they could have commenced so as to make a complete circuit: but practically speaking the proper place to begin was the railway which brought in the raw material to the blast furnaces. Those furnaces were of the modern type, and were the first in Scotland that were fitted with the Cowper Regenerative Blast Stoves; and at the time it was considered an improvement, although now it was so common they were thought nothing of. Their next improvement was to utilize the gases of the furnaces in the way described by Mr Hill. In carrying that into execution, they found it necessary to lay down a general plan of working, and the principle adopted and for which they were striving was this: not to use a single pound of fuel in the works but what went into the blast furnaces, or at least to utilize the waste gases as far as possible. Well, in laying out the works, it was found most desirable to put down one central generator of power,—one battery of boilers, from which there was a service of steam pipes, which made a complete circuit of the works through which power could be taken. Following that, there was a second circuit of hydraulic power for cranes, &c., which followed exactly the same circuit as the other. They had seen how that power was taken off the high pressure pipes and put to work. Alongside those high pressure pipes there was another circuit of what they called low pressure pipes, viz., pipes equal in pressure to about 150lbs. to the square inch. That was a service of water for general purposes, and amongst other things it was used for fire-extinguishing purposes when required. They had an opportunity of seeing how the hose could be attached at various points. The pump which produced the necessary fire-extinguishing pressure was the low pressure pump, which pumped water for the blast furnaces; and should an emergency occur the high pressure and hydraulic could be sent into the same mains, and 10 to 15 jets of water applied continuously, which gave them a great command in case of danger. Even now they had slight explosions of gas, which caused slight fires, and the fire-extinguishing plant had stood them in good stead, and they had no reason to regret having fitted it up. There was another circuit of pipes which ran

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alongside those three circuits, viz., an illuminating gas circuit, from which they took off the gas to supply the various workshops. He need not describe the other parts in detail. These consisted of the foundry, moulding-shops, and so forth, of which many of them had a better knowledge than he had, but one thing he should wish to call special attention to was their system of warehousing. At Carron, they were not only manufacturers, but merchants as well. They sold the whole of their manufactured products, and in those days some of their friends were not disposed to wait for a grate or a stove as at one time, and they must be prepared to supply the article at a moment's notice. In the course of a short time they would have their organization such that they would be able, on receipt of letter or telegram, to despatch any of their stock goods the same day they received the order. (Cheers.) The other parts which made it somewhat of a unique work,—or, rather, somewhat different from other iron-works,—was that they found a post office, a telegraph office, and a railway station inside the place, and from that railway station or platform they had facilities for despatching goods to any part of the kingdom, and he was glad to say the Railway Coy. had such confidence in them, that the work went on with great smoothness. (Cheers.) The brickwork, he believed, would interest them more than dry details of manufacture and business organisation. It was a small concern, arranged for burning bricks for stove-backs, and the special feature was that no fuel was used but waste gas, and it was one of the first works where this was done. It now stood as it had always done without a single alteration having been made upon it, and he was glad to say it had been successful, although were they to reconstruct it they would see their way to make many improvements. He did not think he need take up their time further. He hoped he had said sufficient to give them an idea of the nature of their operations by which, with strict honesty and integrity, they meant to give the public the best possible value for their money. (Cheers.)

Mr RALPH MOORE said it must be very gratifying to the two or three, or half-a-dozen men, including Mr Begg, the first president, who began the Institute. It was a very small beginning, and he was sure they never contemplated ever seeing it what it

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was now. It certainly must be a gratification to the founders as it was to himself to be there at such a splendid meeting. Mr Moore went on to argue in favour of the colliery owners giving more countenance to the Institute by attending their meetings, and of the Institute sending deputations to different parts of the kingdom and the Continent.

The PRESIDENT said he had no doubt the Council would take to heart what Mr Moore had said regarding an excursion to foreign parts. He concluded by proposing a hearty vote of thanks to Mr Brodie for supplying the table with flowers.

Mr COWAN replied for Mr Brodie, who had been prevented from attending.

Mr SMART proposed a vote of thanks to the Committee who had managed the excursion, and Mr Aitken replied.

Immediately thereafter, there was held a

GENERAL MEETING.

JAMES S. DIXON, Esq., President, in the Chair.

Seventy members were present.

The Minutes of the last General Meeting were read by the Secretary and confirmed.

ERNEST ANNANDALE, Bielside, Dunbar,

was elected by ballot, as an ordinary member.

The following paper, by Mr G. B. Begg, on "The Coal Mines Regulation Bill, recently published," was then held as read :—

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THE COAL MINES REGULATION BILL.—RECENTLY PUBLISHED.

By G. B. BEGG, Mining Engineer.

Our examination of the "Coal Mines Regulation Bill," introduced into last Parliament by Mr Secretary Childers and Mr Broadhurst, to secure method and completeness, will compare it with the 1872 Act, which it was intended to supplant, and with which we are presumably familiar. To avoid confusion and allow of speedy reference, the comparison will be, as far as possible, made clause by clause, and only where any alteration calls for attention.

In the 6th Clause, the "male young person" has been disestablished, and we may congratulate ourselves that Mr Childers recognizes sufficient force in the English word "boy" to describe this curious discovery of the 1872 Act; by the word boy he describes all males between ten and sixteen years, but he uses a very awkward phrase in the same clause to describe this individual when above twelve years of age.

The Educational Clauses from 8th to 11th are removed, and by a special clause inserted in the new Bill (§ 69) the enforcement of the observance of these clauses by the employer of children is thrown upon local authorities under the Education Acts, instead of lying as now on mining inspectors.

The regulations for the employment of women, girls, and boys above ground, under clause 12th, is so altered as to allow of Sunday work, the words "or on Sundays" having been removed; but there is yet no allowance for working any sufficient overtime to make up for a shift lost by some accidental interruption or desire for a holiday, except what can be accomplished prior to nine o'clock and within ten hours in any one day.

The exemption of Ireland from the Saturday half-holiday Clause is still continued.

The 18th Clause, as to the appointment and removal of checkweighers for the men, is so modified by the removal of the words "shall be one of the persons employed either in the mine at which he is so stationed, or in another mine belonging to the owner of that mine," that the workmen have now a free choice of the fittest man for the duties they require him to perform; and the office is protected

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by the insertion of the words, "to the detriment of the owner, agent, or manager," in describing the misconduct necessary to warrant complaint or any claim for the check-weigher's removal.

The 20th Clause, requiring double outlets, has been slightly modified. The words "in every seam" have been added to the description of the communication of not less than four feet by three feet required between the two shafts. Further, the word "temporary" has been removed from the description of the purposes of the openings between the mines or outlets which are not to invalidate the objects of such outlets under the Act, and the word "working" has been added to the purposes for which such openings may be applied without affecting the use of the mines as outlets under the Act. These are but small concessions, and only one more important one on this section remains to be noted, that is, that the time within which inflammable gas has been found shall have no effect under this clause, for the words to that purpose have been struck out.

The exemptions from this clause have been considerably altered. Firstly, all the exceptions are to apply only so long as not more than twenty persons are employed underground at any one time in connection with each shaft or outlet. An exception is granted in favour of mines which, prior to 1873, were provided with two shafts, but not at that time separated by ten feet of strata; against this concession, which is not very intelligible, must be placed the removal of the sub-section exempting mines, not being gaseous nor coal mines, which have taken special precautions against danger by stone, brick, or iron mid-walls or linings. It may be that the concession in the one case is to make up for the withdrawal in the other, but they do not appear to cover the same circumstances and are not clear of difficulty in their application. None of the alterations on the clause has great importance, and it is to be regretted that words so often discussed and argued upon, stand in the clause without additional explanation or definition. These words are "every seam of such mine for the time being at work," and the difficulty arises from the word "seam." Is it applied in its geological sense, or can a seam be divided by faults or otherwise in the workings of a mine so as to become

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more than one seam under the Act? This is a difficulty often referred to, and the new Bill leaves the point uncleared.

Clause 26th shows an important alteration on the position and control of Certificated Managers: the object evidently being, and the words clearly requiring, that daily supervision shall be exercised by a certificated manager at each separate mine without freeing from responsibility the official manager in control, who also must hold a certificate. It is to be noticed that all recognition of certificates of service has been withdrawn with Clause 31 from the new Bill, which, however, alludes to them under the clause prohibiting the forging thereof; and it is an interesting question if this alteration means that these certificates are to be degraded and the holders of them, who have worthily filled office and responsibility by their means, are to find their ripe experience and tried skill of no use in the maintenance of their position.

The returns to be made under Clause 38th are to be made a fortnight earlier, and the word "ordinarily" has been left out in the description of the persons employed whose numbers are to be returned. A new return, the return of facts relating to the ventilation, &c., is introduced into the Bill, but as it is one that has for some time been made, the introduction of it has been, no doubt, looked for, and is required to be made at 1st January annually, "and at any other time when required by the Secretary of State."

Clause 39th has a few verbal alterations, for example, the word "whatever" has been introduced into description of the injuries, arising from explosions which require to be notified; also, the words, "or of any explosive" replace the word "powder."

A new paragraph has been introduced into this clause, requiring that the place where loss of life or serious personal injury has immediately resulted from an explosion or accident, must be left just as it was immediately after the accident or explosion, until visited by the inspector, if it can be so left without risk to the mine, or impediment to the working of it.

Clause 40th has a few verbal alterations. The word "seam" is introduced into the first and second sub-section and the word "principal" into the fourth sub-section describing the officers of the company, whose commencement, abandonment, or

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appointment must be notified. New paragraphs have been added to Clause 41st prohibiting the contracting out of the provisions of the Act for fencing abandoned mines and subjecting occupiers of land to the powers of the Act for wilful obstruction to the fencing of such abandoned mines by the parties interested.

The plans required by Clause 42 to be sent to the Secretary of State are altered in description to correspond with the new Bill's description of the plans to be kept at the mine. The second paragraph of the 48th Clause is expanded into a new and very important Clause, directing and regulating the holding of a special court of inquiry in public under an inspector for investigation into the causes and circumstances of any accident. The court is invested with all the powers of an inspector under the Act and of a court of summary jurisdiction and is empowered to enter and inspect any places or buildings necessary, summon and examine on oath any witnesses, demand the production of books, papers, documents, and returns, and is to report to the Secretary of State stating the causes of the accident and its circumstances, and adding any observation which the court may think right to make, and such report may be published if the Secretary of State think fit.

Under the Coroners' Inquest Clause (50th) an eighth regulation has been added by which relatives of persons whose deaths have called for the Inquest, are entitled to appear in person or by agent and to examine witnesses subject to the order of the Coroner.

Under Section 47th the requirements as to plans are altered; thus the direction and rate of the inclination of the seam, and a section of the strata sunk through, or at least a statement of the depth of the shaft, and a section of the seam must now all be shown; and the time to be allowed for production or preparation of the plan demanded by the inspector beyond the 20 days after notice is altered from "shown to be necessary" to "as allowed by Secretary of State."

Such is a detailed description of all the alterations made on part first of the Mines Regulation Act, 1872, by the New Mines Bill, and while most of them are mere verbal altera-

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tions, amendments, or additions calling for no special consideration, some are really far reaching and important alterations which would require careful consideration by the members of our Institute now, while we have time to exert any influence on the progress and effect of this legislation, and especially in regard to part second, the General Rules, now to be compared.

Under Section 51, the General Rules are altered as undernoted:—

(1.) A wonderful quantity of tautology has now been crammed into this rule, for the constant adequate ventilation must now be produced "by day and night throughout the year," and must "purify the air" in which the noxious gases have been diluted and rendered harmless.

A new rule is introduced and regulates the use of ventilating furnaces, requiring either that they shall be sustained with fresh air and have dumb drifts to pass the return air clear of the fire, or that the return air shall all be sufficiently mixed at a proper distance in advance of the fire.

Another new rule requires that mechanical ventilators shall be so fitted and situated that they shall be insured against injury from explosions.

Rules 2 and 3 are combined, and the whole modified and altered to enact that immediately before each shift is to commence work, the fireman's inspection is to take place, and his report must be made and recorded in writing before workmen shall be allowed to enter the mine. The competent person making the inspection must be appointed by the owner, agent, or manager, in writing.

The alteration made on these Rules throws on the workman the responsibility of judging as to the safety of his entry to the mine. The fireman's duty is to make the inspection and record a true report of the same, and nothing as to stating the safety of the mine, or part of the mine, before admitting workmen thereto, except what is required by Rule 5. This Rule enjoins the appointment of stations, beyond which workmen may not pass until the mine beyond the same has been inspected and stated to be safe. This provision suggests the question, Who is to state this? for the duty has been removed from the fireman's

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clause, and not definitely put on any other official. Stations appointed for lighting and re-lighting safety lamps are not to be in the return air.

Rule 7 is altered so far that, like other competent persons who are permanent officials of the mine, the person who is to inspect and examine the safety lamps must be appointed in writing.

A new Rule is introduced specifying distinctly restrictions on open lights, and requires that in any seam of a mine wherein inflammable gas has been found within the preceding 3 months, no other than locked safety lamps shall be used, excepting at the bottom of the downcast, where exposed lights may be used. Further, in any working face or travelling road where derangement of the ventilation would be attended with danger from an accumulation of fire-damp, a locked safety lamp only shall be allowed.

The next rule, also new, requires safety lamps to be safe in explosive currents moving at the rate of eight hundred feet per minute. If a Davy Lamp be used, the shield may be temporarily removed by the person appointed in writing to fire the shots or test for gas. Rule 8 regarding explosives is so altered as to be applicable to "any explosive or inflammable substance," and in subsection (*b*) so that it shall not be taken into the mine but in cartridges only, contained in a secure case or canister of not more that 5 lbs.

Ironstone mines of the Lias formation may be excepted by the Secretary of State from the restrictions of this rule, as far at anyrate as cartridges are required, on application of the owner, agent, or manager.

We are tempted to ask what is the position of paraffin, petroleum, or naphtha, and all the lighter and more volatile oils, which are surely "explosive or inflammable substances," under this rule? Under subsection (*d*) it is enjoined that no coal or coal dust shall be used for tamping. Subsection (*e*) requires that no explosive shall be rammed with violence or forcibly pressed into any hole, and also prohibits the unramming of any unexploded charge. Subsection (*f*) regulating the blasting in fiery mines is so altered as to be practically new. Shots shall only be fired when no one but the necessary officials, who shall not exceed 10, are in the

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seam or other workings on the same shaft level, and only after the place has been examined for gas and reported to be safe by a competent person appointed in writing, and shall be fired only by, or under directions of, a competent person similarly appointed.

A new rule is introduced regarding dry and dusty mines, and requiring them to be protected as follows:—The main air and travelling ways are to be cleared as completely as practicable of dust, and to be subsequently well watered. Shots shall only be fired therein after the place and vicinity have been similarly cleared from dust and watered. "If gas be issuing," the shot is only to be fired in such a way that the explosive shall not inflame the gas.

The vague and shadowy responsibilities of these regulations are so suggestive of immense difficulty that it does not require any more than the mere statement to show their importance.

Rules 10 to 12, as to manholes, are altered as follows:—Engine planes, if exceeding 20 yards long, shall have signals and manholes; and "unless there is room for a person to stand between the side of a tub and the side of the road, such manholes shall be at intervals of not more than ten yards apart." Manholes are now to be kept absolutely clear, the words "to prevent access thereto" having been removed. A new Rule is introduced requiring that horse roads shall be of sufficient dimensions to prevent the horse rubbing on the roof or timbering; but it is not stated that these sufficient dimensions shall exist above the sleepers or rails, and it is possible that a question may arise as to whether it is not sufficient to dig holes as presently between the sleepers for the horse to step into so as to obtain room. Another new Rule respecting timbering is introduced, and requires that the props when set and the sprags shall not exceed a distance apart of 6 feet, or such less distance as the owner, agent, or manager may order; and also, that "in addition to the examination before the men commence work, each working place shall be examined by a competent person at least twice during the shift.

Rule 23 is extended so that it is required that where the drum by which persons are raised or lowered is not on the first motion, an adequate brake shall be applied also to the drum shaft.

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A new Rule requires the providing and maintaining of an ambulance or stretchers at any mine where there are more than 50 persons usually employed.

Another new Rule requires the immediate reporting of any danger existing, by every person employed about the mine who notices its existence, in such manner as shall be specified by Special Rule.

Rule 29 is changed so as to require that the machinery, headgear, working places, levels, planes, ropes, chains, also the shafts, guides, and conductors shall be examined once at least every 24 hours by competent persons, appointed in writing, who shall report regarding the same and record their reports in a book for the purpose to be kept at the mine.

Rule 30 has an addition made to the effect that if the persons employed in the mine fail to take advantage of this Rule, such failure may be recorded by the owner, agent, or manager, in the book required to be kept.

Rule 31 is altered so as now to allow of the destruction of old books 12 months after they have been out of use.

A new clause (§ 46) gives power to the Secretary of State to impose additional Rules after 1st January, 1888, requiring the inspection to be made with a gas indicator capable of detecting 1%, and may prohibit the use of any safety lamps lacking certain provisions for safety such as shut off appliances, or approved lock or satisfactory test in an explosive mixture.

A new clause (§ 61) requires that within 21 days after the hearing of any case raised against any workman for offence under the Act, the result thereof shall be reported to the Inspector.

Such is believed to be a complete vidimus of the alterations proposed to be made on our 1872 Act by the new Bill; but it is only a bare statement of these alterations, and it is hoped that nothing has been done to twist or stretch or in any way distort the proposed provisions of the Bill, so that our consideration and discussion of the clauses may at least start fairly. In submitting the statement it only remains to point out what seems noticeable in the alterations proposed by or omitted to be proposed by this Bill. In the first place it may be fully admitted that the clauses

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are much better arranged and more clearly expressed than previously, and that the doubtful points are much fewer. In another respect the claims of the workmen to certain amendments are acknowledged by their complete admission into the Act. Thus the justiceman and the weighing clauses are now drawn to thoroughly meet their views, and shall therefore thus far give satisfaction to every one, both owner and workman.

In regard again to the Royal Mines' Commission, it is clearly to be seen what effect it has had in this Bill, and it is to be expected that the great difference of opinion will be expressed regarding that influence. A great many of the recommendations of the Commissioners have been embodied in clauses of the Bill, such as regulate the timbering, lighting, and inspection of the mine; and it is evident that these recommendations are much in advance of the great body of the opinion of those interested in mining, and in advance of science too, in so far as the fire-damp indicator is alluded to, for this instrument is not yet more than an instrumental curiosity, and it is surely early to introduce it into practical use by legislative enactment. In regard to the dry and dusty mine clause, too, a great diversity of circumstances exists, and this shall most probably suggest as great a diversity of opinion as to the requisite provisions. But who is likely to be satisfied with the clauses appearing in the Bill? They are too vague and indefinite, and, like many of the other clauses, require too much confidence to be placed by the owners in the moderation of the views and aims of the Inspectors. It does not seem impossible to draw the clauses for the necessary provisions so that the duties and the responsibilities lying on the owners, agents, or managers in the face of an acknowledged danger under circumstances of serious difficulty may be defined in some reasonably approximate form.

Nothing has been enacted by the new Bill to protect the country against the waste and destruction of the minerals by objectionable methods of working, or by irregular or hurtful order of working the different seams, or by unnecessary leaving of barriers against marches. Nor does there appear to be any desire to legislate on the subject of minerals under water level. Such questions are left out of the powers of the Act

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altogether unless the Inspector can bring his arbitration clauses to bear. Another question, too, is—Are limestone workings of the coal measures to be left without any advance in their legislation, although they are known often to yield gas in great quantities and are not free from other accidents?

It is desired that our consideration and discussion of the Bill will not be without benefit both to the proposed legislation and the views of the members of our Institute.

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THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,

30th SEPTEMBER, 1886.

JAMES S. DIXON, Esq., President, in the Chair.

Fully 40 members were present.

The Minutes of the last General Meeting were read by the Secretary and confirmed.

The following were elected by ballot as Ordinary Members:—

AZARIAH GRIFFITHS, Falkirk.
JAMES A. TWEEDIE, Carron Works, Falkirk.
DANIEL MILLER, C.E., 204 St. Vincent Street, Glasgow.
ROBT. B. DENNISTON, M.E., 79 Princes Street, Dunedin, N.Z.
WM. N. SHORE, Raitangata, Dunedin, N.Z.
JAS. R. M. ROBERTSON, M.D.M.E., Sydney.
ROBERT SHARP, Coatbridge.

The following discussions were then proceeded with:—

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DISCUSSION OF MR BURNETT'S PAPER ON "BURNETT'S ROLLER MINING WEDGE AND DRILLING MACHINES, WITH AN ASSOCIATED SYSTEM OF COAL-GETTING," AND THE COMMITTEE'S REPORT ON TRIALS AT GREENFIELD COLLIERY.

Mr JAMES HASTIE, in response to an invitation from the President to open the discussion, said as Mr Burnett was not present, he would not like to say much about the wedge, but he would be glad to answer any questions.

Mr ROBERT BEITH said he did not see that they could go much beyond the point reached at last meeting. They then expected to have more experiments, but unfortunately they had not had them. If these had taken place, they would have had a better test by which to ascertain the percentage of dross made with the wedge compared with other methods. With regard to the merits of the wedge, he believed, if blasting were prohibited, there would be a chance of it getting on by arranging for a division of labour, viz., appointing men to go on with the holing and wedging, while others were filling behind.

Mr JAMES SMART said he supposed that no gentlemen accepted Mr Burnett's offer to test the machine for three or four weeks, so that the proportion of dross might be ascertained.

The PRESIDENT said he was not aware, but he had had a correspondence himself with Mr Burnett on the subject, with the view of testing the machine in Hamilton Palace Colliery. He had not yet arranged the matter, but that day he had had a note from Mr Burnett stating that circumstances had prevented him from communicating with the speaker since his (the President's) last communication some time ago, and that he would hear from him again shortly. There were but a limited number of places and not a very large output at the colliery, and his proposal was that Mr Burnett should do the wedging for the whole output for say a month, and compare the results with those hitherto obtained. It would not be a comparison between powder and wedging, but between hand wedging and machine wedging because they did not use powder.

Mr SMART—Perhaps it would be better if powder were taken into consideration too.

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Mr HASTIE said he could answer for powder. He was experimenting for twelve weeks and taking a note of the amount brought down compared with powder, and he found the results with the wedge did not equal those with the powder. The experiments were carried out in the usual way of working, and it was simply a comparison of the weight of triping.

The SECRETARY—That is hardly fair. The respective proportions of round and small by the two methods should be taken into account.

Mr F. J. ROWAN said he noticed in Mr Gemmell's review of the Report of the Royal Commission on Accidents in Mines several wedges were mentioned as having been experimented upon by the Commissioners. At p. 117, there were three mentioned. It might be interesting to know how far they differed from Mr Burnett's wedge, both in their system of working and in their efficiency. One of them,—the last, he believed,—was very fully described in two papers in the Transactions of the North of England Institute and of the Cleveland Institute. He referred to Mr Hall's wedge.

The PRESIDENT said he thought they were unanimous that Burnett's wedge was a powerful instrument for the purpose, and probably the best introduced. It was more a question whether it could be worked alongside either hand wedging or powder to advantage.

Mr DAVID DUNN said there was no element of cost, he presumed, in the comparison made between wedging and powder. It was a question of safety. He fancied from the remarks made that it was proposed to compare the cost of getting coal with those wedges as against powder, but how could that be?

The PRESIDENT—Mr Burnett claims to make such a small proportion of dross that he thereby makes up for the extra labour required.

Mr DUNN—But there can be no satisfaction got out of a comparison between the cost of wedging and powder unless some of the members are prepared to state clearly what it is costing per ton for powder. Where coal was got by powder, he had got as high as 13 tons per lb. used, and as low as 9 tons. That was over two years' workings.

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The SECRETARY said, in reference to Mr Rowan's inquiry, it would of course be interesting to have the results of the operations of other wedges, but unless they were brought to do the same work as Mr Burnett's wedge, and compared at the same time in the same seam, a fair comparison could not be got, and so with gunpowder. Although a certain result might be got here and another there, they must be got together in the same working to be of any use as a comparison.

Mr JAMES GILCHRIST said, at the time the experiments referred to in the Royal Commissioners' Report were made, Mr Burnett's wedge was not in existence, or at least had not been brought before the mining world, for in a foot-note, page 63, the Commissioners mentioned that a wedge had been submitted by Mr Burnett, but too late to be tried. As to the question of comparison with gunpowder, it might be very difficult probably for any one to arrange for such a trial, but the Council of the Institute might be authorised to try and arrange it if it was thought of importance that such a comparison should be gone on with.

Mr D. JOHNSTONE said one thing Mr Burnett claimed was that the coal got by means of his wedge stood the handling better for shipping purposes than the coal brought down by powder.

Mr SMART said what they would like to know was how much less dross was made by Burnett's than with the regular wedging of the coal by hand.

Mr DUNN thought it was a fruitless task to compare the cost of getting the coal by wedging as against powder.

Mr HASTIE said that was the reason why he said there was no comparison between wedging and powder. He thought Mr Burnett's wedge far superior and cheaper than the ordinary way of wedging in any seam.

The PRESIDENT said the trials he had referred to might be begun by next meeting.

The discussion was then adjourned.

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DISCUSSION OF MR GEMMELL'S PAPER ON "THE WORK OF THE ROYAL COMMISSION ON ACCIDENTS IN MINES."

THE PRESIDENT, in introducing the discussion on this paper, said it went over a very wide field of subjects, and was certainly a paper that did great credit to its author.

Mr DUNN said he thought it was a question for that Institute to ask, "Has the Commission fulfilled the purpose for which it was appointed?" Regarding ventilation, he thought, they should have drawn a hard and fast line regarding the amount of ventilation that should be in a mine or section of a mine. If this were so, he did not think it would be in the interest of any mine-owner to object, and they would hear less of explosions, especially if ventilation was taken to the face as in many cases it was not.

Mr BEITH said he would like to hear from Mr Gemmell or some of the members a suggestion as to the best mode of dealing with coal-dust. There were various methods already in existence: a water tram or chest for watering the roadway; pipes were also laid along the roadway with taps at intervals of from 50 to 100 feet, to which a hose could be attached; and in Wales a system was being introduced of having pipes with small jets and sprays issuing from them, and carried by the ventilation, so as to keep the dust in a moist state.

Mr RALPH MOORE—The Commission had dealt at length with two points,—with ventilation and safety lamps, and it would have been a world of trouble, without a corresponding good result, to have done more than they had done. It was many years sitting, and had given the most valuable experiments he had ever seen by any Commission. The paper before them was a very fair review of the Report, and to those who had not the Report the paper gave a sort of idea of the principal points. He thought they should have from that meeting, composed of practical and scientific men, a very thorough investigation of the subject; for, no doubt, legislation would follow on the Report, and it was very right that the views of this and kindred Institutes should be placed before the Legislature.

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Legislators were not expected to be practical men, and there was no doubt the opinions of an Institute such as that would have consideration with them. Mr Dunn said it should be enacted that there should be a certain number of cubic feet of air in a pit. If the Institute was of that opinion, they should say so. Of course, in his official position, they could not expect him to give any opinion at this meeting, but the subject was of very great importance, and they would certainly fall short of their duty if they did not give expression to their opinions not only on the Commissioners' Report, but on mining legislation. For instance, safety lamps had been brought very prominently before their knowledge in a circular he had sent out. There would be action taken on that—that was to say, those using safety lamps would be asked to use the best ones. The Report was the most important on those two subjects that had been issued in his time, and he was very anxious that the full weight of it should be before them.

Mr HENRY AITKEN said he was of opinion that the experiments with the gas indicators and particularly with the platinum were not to be relied on. Some ten years ago and more, he saw this subject gone into, and found the results were so unsatisfactory they were not to be depended upon. The experiments were made generally with common coal gas, but sometimes with natural gas. He had never got gas (fire-damp) free from carbonic acid. What was the effect of that carbonic acid along with the fire-damp? What part did it play as a preventer of explosions, or, after a given time, when it got to a certain point did it not make the fire often stronger though not quite so rapid as if there were no carbonic acid in it? That was one of the points some one scientifically inclined, ought to go into. Sometimes he had seen so much carbonic acid mixed with air and fire-damp in a mine that it would scarcely "fire." In such a mixture, he did not think that any of those indicators were of much use. As regards the proposal to saturate the air with damp in order to keep down the dust, the air would only carry moisture to its temperature, and he understood that the health of the workmen suffered from breathing air always fully charged with moisture.

The PRESIDENT said he quite agreed with Mr Dunn that a

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Commission appointed for the purpose of showing them the way to decrease the number of accidents in mines should have been more definite in their statements. He thought if they had come to a conclusion and asked them to carry it out, then they could have got some practical benefit from their recommendations. Otherwise, they were very much where they formerly were. They should have said, "There is an instrument; use it," and there was not a colliery proprietor but would have adopted it.

Mr RALPH MOORE was sorry to differ from the President, but really he looked upon the Commission's Report from rather a different light. The Commissioners said, "Gentleman, we find certain things; we find gas behaves in a certain manner; we also find what the effect of these indicators is; but these are all points put before you, and it is for practical coalmasters to get the best remedy that can be got." He thought the Commissioners acted very wisely, and he very much admired the way in which they did not lay down any very hard and fast line, but said everything must be reduced to practice. He thought they were more able than the Commissioners to deal with those points. Then, as to the lamp, in the same way he thought it would be very rash to say they should use a certain lamp. There were improvements being made every day. He remembered when there was an outcry against wire ropes, and a strike lasted eight months because the men would not ride on wire ropes. They would not act in that way now. It would not do to say that they should have one kind of lamp.

Mr DUNN said he believed the introduction of Davy lamps in a mine raised the cost of production from 2d to 4d per ton, and while they might not get dirtier they got small coal. The men could not go about their work in the same way. There was a very great deal more danger apart from fire-damp altogether. They could not see the dangers in the roof so well. He submitted that although it did cost a bit of money to do so, it would be cheaper to improve the ventilation than to work with Davy lamps and all the danger attending them.

Mr RALPH MOORE said they were speaking now of safety, and as for cost, the public must pay for that. Mr Dunn had raised another question. If he understood him aright, he said a mine

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with safety lamps was not so well ventilated as one that was not. He would join issue with him there. His experience was the very contrary. The mines with safety lamps alone were the best ventilated mines they had. No doubt of it; and it was very easy to show how, because the discipline was better, and the mines were better laid out.

Mr DUNN replied that he did not say that because a mine was worked with Davy lamps it was not ventilated. He said safety first, cost next, but safety by all means. In addition to the question of safety, he said there was an important one to every miner and manager, viz., the cost of paying for the ventilation, and, if possible, doing away with Davy lamps, by which they had not only absolute safety but less cost. That was his point, but by all means safety first.

Mr HASTIE said he thought Mr Dunn's argument amounted to this, that a mine should be ventilated in such a way as to be worked with naked lights.

Mr ALEX. FAULDS begged to agree with the President as regards the Royal Commission. Their report, after sitting several years, would be very useful, but would have been more so had they drawn hard and fast lines to have gone by, and at the same time suggested the best safety lamp to be used under the different circumstances, whereby mining operations could be be conducted, if possible, with more safety.

Mr AITKEN said he thought there seemed to be some confusion as to what was the duty a Royal Commission had to perform. It was not to make laws. It was to arrange facts. This they had done. They were asked to do no more, and he thought what they had done, they had done well. He agreed with Mr Moore that this was a matter that should be taken up and fully discussed, and he thought also that the discussion upon the proposed Mines Bill should go along with it, because the two subjects were so intermixed that it was practically impossible to separate them.

The PRESIDENT said he quite agreed that the Commission had very admirably gone into the facts and collated and reported them, but he would have liked if they had, if possible, drawn more decided conclusions than they had done. He did not want

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them to legislate, but they might have been more conclusive in their indications of how legislation should be shaped.

The discussion was then adjourned.

DISCUSSION OF MR M'KINLESS'S PAPER ON "A GAUZELESS SAFETY LAMP."

Mr M'KINLESS briefly recapitulated the leading features and advantages claimed for his lamp.

Mr RALPH MOORE commenting on the air outlet, said it looked very much like one of the Belgian lamps he had seen. As to the top, he had never seen a lamp fail at the top. During the past month, in the course of some experiments, he had seen a lighted lamp with a hole an eighth of an inch on the top put into a reservoir of gas, and it did not explode the gas outside, because the products of combustion passed through the hole. Yet, if they put a hole of that size anywhere within an inch of a light it exploded outside at once. Unless there was anything in the cost of this lamp that was a saving, he saw nothing in the lamp very wonderful or that took it out of the category of the lamps presently in use.

Mr M'KINLESS said he did not claim anything very wonderful for the lamp beyond this: it could not be exploded, and their gauze lamps could.

Mr DUNN asked in what proportion would the mixture of firedamp require to be to cause the lamp to explode.

Mr M'KINLESS said the lamp would go out in any mixture of gas that was dangerous, and that was what they wanted. The cost was 10s 6d each.

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The PRESIDENT said he thought they were at one as to the efficiency of the lamp as a safe lamp. He wanted to have some information,—and he believed there were some who had tried it,—as to how it burned, and how often it had to be trimmed, and whether it could be used by drawers and pony-drivers and people who were moving about. The Protector lamp in such circumstances went out too easily; otherwise it was a very good lamp. The circular Mr Moore referred to, he thought, indicated that there was to be a move made against certain lamps now in use. Those lamps were used in the circumstances to which he alluded. Therefore, if that were so, what they wanted was a good lamp to be used by pony-drivers and others. A miner could hang up his lamp and work away for hours, and they had lamps that fulfilled that condition, but they required another to meet those other requirements.

Mr BEITH said he had tried the gauzeless lamp for two or three days, and he thought as a carrying lamp it burned very much better than when hanging up, but even carrying it, it required a good deal of trimming. He thought the burner was too high, for burning the best colza oil they had to trim it five or six times a day. From what he had seen of the lamp it compared unfavourably with the Protector Mueseler.

Mr MOORE suggested that some one make comparison with the Williamson and any other lamp using oil.

Mr FAULDS asked if the holes drilled in the funnel were more easily kept free from dust than the meshes of a gauze.

Mr M'KINLESS said he found the trimming to be a very important point. He had now got a new oil,—he did not know what it was, but it was supplied by a firm in Newcastle; and by using this oil, they could burn the lamp a good long shift without touching it with a pricker. He had got several letters acknowledging that to be the fact, and he thought if they could get a lamp to burn seven, eight, or nine hours without even touching it, it could not give much trouble. He had had it burning ten hours in a room, and if they trimmed it properly with the top of the flame level with the bottom of the chimney they would not require to use the pricker more than once, and that to raise the wick simply. It had a wider light than the Protector Mueseler against which he

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had no wish to say anything The Protector Mueseler was considerably more sensitive, and would not stand the usage this one would. They could jerk this one up and down (showing), or swing it rapidly.

Mr BEITH said he was of opinion that the lamp was throttled in the outlet, because after trimming and lighting, it burned very brightly, and after putting it inside, the flame went down.

Mr M'KINLESS said he had over eighty firms trying the lamp; they had received orders in bulk from six or seven, who, before giving the order had had it in use since March. He thought that was a fairly long experience. They had had three complaints of the top holes being choked, and in each case they had satisfactorily proved that it was not the fault of the lamp but of the oil.

Mr DUNN asked what had been the effect of the coal dust on the perforations.

Mr M'KINLESS said that had been discussed, and a gentleman said at one of the meetings that he had had it in dusty workings for an entire shift without any inconvenience.

The PRESIDENT said there were a number of parties present who used the lamp to which Mr Beith had referred, viz., the Mueseler Protector, and one great advantage of it was that it did not require to be trimmed at all. It would burn for twelve, fourteen or sixteen hours without trimming. It burned spirit absorbed in a sponge,—therefore, without any danger from explosion. The others had to be taken to the cabin to be trimmed, opened and a light struck. Besides the time lost to the miner, there was that disadvantage. He thought if Mr M'Kinless or any other inventor of a lamp could get with a better light the same results with a like amount of safety it would be a great object. The question of lamps contained in Mr Moore's circular was an important one, and he thought as an Institute they might take up the matter by the appointment of a committee to visit collieries and report as to the best lamp that could be got to replace the Scotch gauze lamp. In the Hamilton district, and throughout Lanarkshire generally there were thousands of them in use. Of course the putting of them out of use would be a question

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for arbitration, but it might be well for them to take up the matter and be able to adopt the best lamp suggested. It was a point they were all interested in.

Mr JAMES GILCHRIST said he quite agreed with the suggestion that a committee should be appointed to examine the different safety lamps with the view of adopting the best one in lieu of the Scotch gauze lamp. That lamp they were all aware, was the most expensive they could use, and speaking for himself, for sometime he had been trying to get some other lamp to adopt instead, but the difficulty was to get a good one. The Protector Mueseler was no doubt a very good one for a collier, but he was afraid a lamp burning spirits would not suit the drivers and other oncost men who have to carry them continually about. The lamp of M'Kinless, according to Mr Beith's report, would not answer the purpose, for it had to be trimmed four or five times a day, but possibly, with the new combination oil, he would overcome that difficulty. However, he thought the lamp most likely to be adopted would be one that burned the ordinary oil in use, as there was sometimes a difficulty in working with those special oils.

The PRESIDENT said he regarded the Scotch gauze lamp not only useful for travelling about with, but for examining the roof in brushing or in places where there was a bad break, and that was a point to be kept in view in suggesting a lamp. As the Commissioners said, by avoiding one danger, they were apt to run into another. and that might be the result here. The Scotch gauze lamp had been very useful; it had been used for half a century, and he did not know that any disaster could be traced to it.

Mr SMART said when this subject was last before them, the President asked the question if they could burn spirit, and Mr M'Kinless said yes. He asked if the spirit could be applied the same as to the Mueseler.

Mr FAULDS repeated his question whether the holes in Mr M'Kinless's lamp were more easily kept clean than the meshes of an ordinary gauze lamp.

Mr M'KINLESS said he had not had much to do with the cleaning himself, but he had referred to those who had, and they had simply used a hard brush and it was as easily cleaned as gauze.

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With regard to the oil, the Royal Commissioners recommended a compound consisting of two-thirds seal or rape oil and one-third petroleum. He had made a number of experiments, but had not been able to obtain any mixture that answered the purpose so well as the oil of the Newcastle firm to which he had already alluded. They were not oil dealers, and he recommended this one because it gave such excellent results. With regard to the spirit, this lamp could be made to burn it, but they would have to alter the construction of the bottom of the lamp.

The SECRETARY said it appeared to him that this lamp deserved some attention. He thought it would be well if the discussion was adjourned until another meeting, because they had a very distinct expression of opinion by Mr Beith founded upon rather a short experience, and it might be too unfavourable to the lamp to close the discussion on the faith of that opinion only. He thought it would be well to have the lamps put into the hands of others of their practical men so that they might have other opinions based on practice.

The discussion was adjourned for this purpose, and a remit was made to the Council to appoint a committee to inquire after and report on a substitute for the Scotch gauze lamp.

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DISCUSSION OF MR G. B. BEGG'S PAPER ON "THE COAL MINES REGULATION BILL RECENTLY PUBLISHED."

Mr AITKEN said, in the proposed Bill, the primary object aimed at was to legislate for the safety of the workmen. On this point they need not say more, as it had been already conceded by all the gentlemen who had taken part in the discussion on Safety Lamps. While that was so, they must not lose sight of the other point that, as people had to live, it was necessary to work the coal, and that the Act should be so framed that it would not only effect the safe working of the mines, but would contain nothing that was factious in character; in short, that the law should be made for the mines, not the mine for the laws. They should bear in mind that at the present time the mining industries were not in a state that could stand being trifled with. Foreign competition was too keen; and, however desirable it might be to make the laws as stringent as possible, they must be careful not to raise the cost of production. They had too much idle labour in the country and too much unproductive capital to play with the subject at the present time. Of course, while all that was true, it was equally true that the safer they conducted their mines the cheaper they would get labour, because the more readily would such labour be entered upon. The old Act certainly did require amendment and additions. Much in the proposed Act also required amendment; much required to be added to it in order to make it what he conceived was required. The first addition he would propose to the Bill was to the latter portion of clause 13, p. 5, where power was given to dismiss a justiceman who had done anything which the judge might think improper. That was so far right, but he should propose to supplement that with a clause to the effect that he (the justiceman) could not afterwards be employed at any mine belonging to said owner. As the clause stood, he might be brought back again, and all the expense and trouble of putting him off lost. The next point he would direct their attention to was clause 20, p. 9:—"Every mine to which this Act applies, shall be under the daily supervision of either the manager or some person holding a manager's certificate and nomi-

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nated in writing by the manager to exercise the functions of such daily supervision." This clause meant a very great addition to the expense of working, and he also submitted that it added nothing to the safety. The men who made the daily inspections were, as a rule, experienced practical working men that knew an unsafe roof much better than many of the men who carried certificates; and he held that the present type of inspection was better than the one proposed. It would be impossible to put this clause in force at present, because they could not get the number of certificated managers to accomplish the work, and before this clause could pass into law, supposing it was found necessary to do so, they would require several years to get certificated men ready. The clause went on to say, "But such nominations shall not in any wise impair, alter, or affect the personal responsibility of the manager under this Act." Under this clause, a manager is held criminally liable for an act of his neighbour, and he submitted there was no law in any country that did this. It was necessary that this most unjust proposal be taken from the Bill. He held also that it was necessary that this clause should be altered to make it more clear what was meant by the word "mine," as it seems clear that, if the "interpreted" meaning of the word mine was applied, it covered more ground than what was intended. This difficulty as to the meaning of the word "mine" not only occurred in this clause, but in many places throughout the Bill, and he thought a clear definition of the word "mine" was absolutely necessary.

He submitted there should be added to Sub-clause 3, p. 21 :— "Nor shall such person be or have been employed in any employment or office in or under which he draws or has drawn fees, pay, or remuneration, either directly or indirectly, from the Government, unless when acting under the provisions contained in this Act."

He then referred to the General Rules :—

Rule No. 2.—Delete "proper," and add after "distance" "of not less than yards."

Rule No. 3 should be enlarged, and the proper position of the "mechanical contrivance" for causing ventilation stated; also that this rule does not apply to such "contrivances"—he presumed fans—already erected.

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Rule No. 3.—It should be stated whether or not the inspector here referred to is in addition to the one under Clause 20, previously referred to. It is not clear whether three or four daily inspections are required. (See Rule 23.)

Rule No. 9.—He held that it must be conceded that the present position of the *law* as regards where safety lamps should be used was all that could be desired, but the application of the law was defective. It was a matter of daily comment in the trade why one colliery should be worked *entirely* with safety lamps, and one alongside, where the risks of explosion were quite as great, was worked only *partially* with safety lamps. It will be generally conceded that 2d per ton does not cover the extra expense of working with safety lamps compared with open lights, and yet we have some employers losing this in order to get the greatest safety, while others not believing any danger use open lights. It is impossible to understand what is the object of two sentences which follow this rule.

Rule No. 10.—The time is too short to admit of getting the necessary lamps; two to three years should be allowed. It was to be noted here that Government did not seem to have the slightest regard for the expense mine owners were put to. It practically confiscated so much of the employers' property and gave no relief. In some collieries this loss to the employers would be hundreds of pounds. It was also to be noticed that it may in like manner, at any time in future, order a different kind of lamp to be used.

Rule No. 11.—Add after "person," third line, "or persons."

Rule No. 12.—Add after "substance," "used to create an explosion."

Rule 12, S. I. and II.—Unless these clauses were modified, it would be necessary to shut up some collieries, and in any case it would increase the cost of working. A very full discussion is necessary before coming to any determination as to what modifications were required. Meantime it may be noted that the word "level" may mean anything or nothing.

Rule No. 13.—This rule required very careful consideration and discussion. Difficulties, in many cases well nigh insurmountable, had to be overcome, and he feared that its application would

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in all cases be very costly. The application of such a rule to mines where there was no fire-damp seemed not to be required.

Rule 18.—It would be interesting to know the reasons which had suggested the insertion of such a rule. It should be struck out.

Rule 23.—The first idea which occurred to him on reading this rule was what was meant by the words "working places." Is a road the working place of a drawer? The second idea was what was meant by the words "is done by the workmen." Who else is there to do the work? Then came the third idea, what was a "convenient place?" These "wordings" might be got over, but the requirement contained in the three and one-half lines from the top of page 29 are, he ventured to say, what would not be proposed by one dozen colliery managers in Scotland. To put up timber every six feet in all working places, rooms, wall faces, roads, whether it is required or not, seemed, to say the least of it, a curious rule. If timber is put up when required, what more is necessary? He would propose to delete the three and one-half lines above referred to and substitute the words "and shall be put up by the workmen in the roadways and faces so as to secure the roof and sides." It was to be noted also that the *onus* of proper propping, by this rule, was thrown on the owner, agent, or manager. This was not what should be. The man working the coal should be responsible, and he should put up his timber. This to be a general rule; exceptions there are to all rules. The concluding sentence of this rule requires two inspections to be made in each shift. These inspections are in addition to the inspection under Rule 4, but it is not clear whether the inspection under Section 20 is to be considered one of these inspections or not. It should be specially noted that the old Act only required one inspection in addition to the morning or "start of shift" one.

Section 46.—There should be a court of appeal from the decision of the Secretary of State.

He would not enter farther into the matter, feeling that he had taken up too much time already. He would conclude with a motion: "That this meeting respectfully desire the Council to continue to call the members together until they shall have fully discussed the Bill; and that, so soon as this shall have been done,

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and the various changes and additions proposed have been formulated, they shall send to each member a copy of such proposed changes and additions, and ask his opinion thereon, the result of such opinions to be thereafter forwarded to the proper quarter."

The discussion was then adjourned.

NOTES ON EXPERIMENTS WITH SETTLE'S PATENT GELATINE-WATER-CARTRIDGE AT EARNOCK COLLIERY.

By James Gilchrist.

At the request of the Council I agreed to prepare and lay before the Institute the result of some experiments with what is now known as Settle's Patent Gelatine-Water-Cartridge.

Nobel's Explosives Company, Ld., Glasgow, having acquired the sole right to use Settle's Water Cartridge, they claim that when used with their Gelatine-Dynamite, there is absolute safety in blasting underground, and no smoke or fumes after the explosion.

It is said that this system of blasting coal has been perfected and successfully introduced into a great many collieries in England, and Nobel's Company are now trying for the first time to introduce it into Scotland, and for that purpose they made arrangements with Mr Watson of Earnock that the first trials in Scotland should be made at his colliery near Hamilton.

In the Report of the Royal Commission on Accidents in Mines at pages 60-61 it is stated:—

"The employment of nitro-glycerine preparations, such as dynamite and gelatine-dynamite, or of such gun-cotton prepara-

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tions as compressed gun-cotton, cotton-powder, tonite, or potentite, in conjunction with the water-cartridge, secures safety against the production of explosions, even by blown-out shots, in mines or workings where the air may contain a highly inflammable dust, thickly suspended in it at the moment the shot is fired, besides any proportion of fire-damp below that needed to produce a violently explosive mixture of the gas and air. Moreover, when used in this way, they efficiently replace ordinary mining powder for working in coal. . . . The employment of any of the explosives of the kinds above indicated, or of any other so-called high explosives, similar to them in character, in conjunction with a porous tamping, soaked with water—ordinary moss being a convenient material for the purpose—secures safety against explosions, not only under the circumstances above-named, but also even if the shot thus loaded be fired as a blown-out shot in the presence of a highly explosive mixture of fire-damp and air. This mode of applying the violent explosives, besides insuring safety under certain circumstances when the use of the water-cartridge may not afford perfect security, presents the additional advantages of simplicity and cheapness. The local shattering action of the violent explosives does not appear to be always modified by the employment of a tamping of water applied through the medium of a spongy solid, to the same extent as is the case with the water cartridge; but gelatine-dynamite has been found to compete well with powder in some descriptions of coal when employed in conjunction with porous tamping and water. For blasting in roof or floor, or for working in stone drifts, wherever fire-damp is liable to occur, the violent explosive agents, employed in conjunction with sponge (moss) and water-tamping may be said to leave nothing to be desired in regard to the combination of efficiency with safety."

After some preliminary experiments had been made with the water-cartridge in different ways, the Council of the Institute and a number of other gentlemen were specially invited on the 23rd September to witness further trials. These trials, as reported in the daily press, were considered satisfactory, but the following particulars will enable the members to form their own opinion.

The appliances required for blasting are as follows :—

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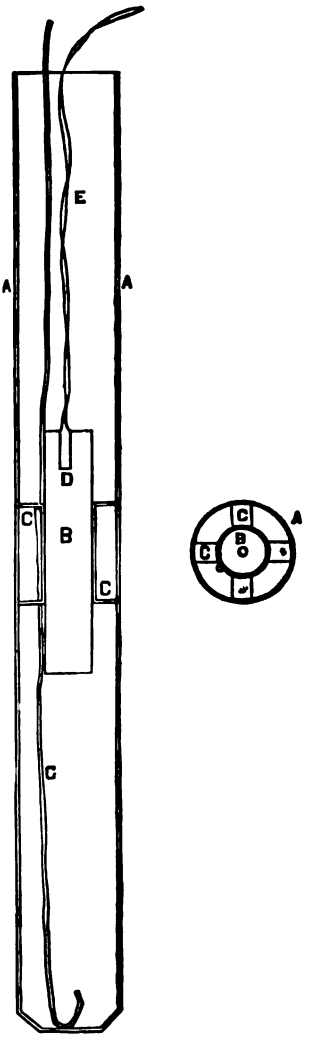
A mechanical drill or boring ratchet, to bore a hole four feet deep and two and a quarter inches in diameter.



SECTION OF WATER CARTRIDGE.

A, Water Case. B, Gelatine Dynamite Cartridge. C, Cartridge Support. D, Detonator. E, Wires connected with Detonator.

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A water cartridge case. These cases are made with a specially-prepared paper, coated with a solution of india-rubber; they are eighteen inches long and two inches diameter.

Next in order comes a cartridge support, which is made with a small piece of tin and a wire.

For every shot fired an electric detonator fuse is required; the wires connected with the detonator are 54 inches long; then, with a supply of gelatine-dynamite in cartridges, a can full of water, a lump of good stiff clay, and a piece of cord, the operator or fireman would be in a position to charge the holes for blasting.

To fire the shots the fireman must also carry with him a magneto exploder or battery; 50 yards of copper cable, and a fuse protector; the fuse protector is a tube 40 inches long, and tapering from $\frac{5}{8}$ of an inch to a $\frac{1}{4}$ inch.

The magneto electric machine for firing the water cartridges is a modification of the machine devised by Clarke, and consists of an armature revolving between the poles of a compound permanent magnet.

This armature is a solid forging of the best wrought iron, and wound with about four thousand turns of silk-covered wire of the highest conductivity. After winding and insulating, the armature is immersed in melted paraffin, dried and coated with a special hard India-rubber varnish, and is thoroughly waterproof.

The pole-pieces are made of malleable iron, and are bored out with a boring bit, so as to allow only the slightest clearance for the movement of the armature.

The magnets are of special steel, and are the strongest it is possible to make, being magnetised by a special process of the makers, and capable of lifting fifteen times their own weight.

The driving power is effected by means of a wheel and pinion both of brass.

The machines are made in various sizes; those usually supplied weigh $6\frac{1}{4}$lbs., giving an electro-motive force of 1·2 volts, and capable of firing up to six shots at once.

The following Rules should be observed in blasting with the Water Cartridge:—

Only perfectly water-tight outer cases should be used.

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The charge should consist of only *One* Cartridge of gelatine-dynamite of a suitable size.

After the electric fuse has been carefully attached to the gelatine-dynamite charge, and the cartridge support adjusted, and placed in the outer case, the outer case should be filled with water, and the open end closed, by inserting a small piece of wet clay, and tying the end tightly.

The wires of the electric fuse should be put into the fuse protector, and then the charge is ready for being put into the shot-hole.

After the first six inches of stemming has been placed loosely next the charge, the hole must be tamped up to the mouth most thoroughly. Good hard clay is the best stemming, and a wooden stemmer only should be used. When stemming, the fuse protector should be gradually drawn out of the hole.

When stemming is completed, fix the wires of the cable to the wires of the electric fuse, taking care to make a perfect connection, and to do so, the ends of the wires must be bright and clean.

The connection of the cable with the magneto exploder or battery should not be made until everything is ready for firing, and the workmen have retired to a safe refuge.

After firing the shot, disconnect the cable from the battery before proceeding to examine the results.

The experiments on Thursday the 23rd September, were made in the Main coal seam, which is wrought longwall. The depth from the surface is 128 fathoms.

SECTION OF SEAM.

	Ft.	In.
Roof, Fakes.		
Gas Coal, ...	0	6
Free Coal, ...	0	5
Splint Coal Rib, ...	0	2
Free Coal, ...	1	11
Splint Coal, ...	0	7
Free Coal, ...	0	9
	4	4
Pavement, Fireclay.		

The working place where preparations were made to fire the first shot was holed 6 feet deep, and the height of the

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holing at the front was 20 inches. The face of coal was half-end and half-plane, and had a fair roof parting. The shot-hole was bored 4 feet deep by 2¼ inches diameter, and if the shot had been fired in the usual way, with powder, half a pound would have been used; but with the water cartridge one cartridge of gelatine-dynamite was used, 5 inches by 1 inch dia., weighing 3 ounces. After the hole was charged, all the party retired to a safe distance; but a number of practical gentlemen had a good view of the hole, so that if any sparks or flame were given off when the shot was fired, they would be sure to detect them. After the order had been given to hide all the lights so that the place was in perfect darkness, the signal was given to fire. This was simply done by turning a handle and pressing a knob on the battery at the same time. All those who were watching the hole were unanimous in declaring that there was not the slightest appearance of sparks or flame. The result of the shot was about 30 cwts. of coal brought down, leaving some coal hanging loose; but the coal did not come down to the back of the hole. Very little smoke was given off.

Another shot was prepared in the same place, but in this case the holing was only 5 feet deep. The hole was 4 feet by 2¼ inches, and bored within 18 inches of the solid coal, so that this shot was fast on one side. Had powder been used a little less than half a pound would have been sufficient; but as the last shot did not do as much as was expected, a larger cartridge of gelatine-dynamite was used for this shot, weighing 3½ ounces. When the shot was charged and everything ready, the party retired again. All the lights were hidden, so that if any flame was given off it could be easily detected by those watching; but when the shot was fired not the slightest sign of flame was observed; but in this case smoke was given off, and had a slight smell, but was not as bad as if powder had been used. The coal in this case was brought down to the back of the hole, but the coal round about the hole was very small. The holes were bored in the free coal under the gas coal.

The next shot was fired in the brushing (fakes) on one of the main roadways. The road was 7 feet wide and the brushing 2½ feet thick; the shot hole was 4 feet deep, and 7 oz. of gelatine-

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dynamite was used for the charge. It was reckoned that 2½ lbs. of powder would have done the work.

In this case there was some difficulty in getting so much gelatine into the water cartridge, but at last it was managed; then stemmed and fired in the usual way. No flame or sparks were noticed when the explosion took place. This shot blew 15 inches over the hole, but did not bring the sides very well down: possibly it was overcharged.

Several days after, a powder shot was fired at the same place, under similar conditions, with 2½ lbs. of compressed powder. This shot blew six feet over the end of the hole, and brushed the sides much better than the other shot did.

After the shot was fired in the brushing, the party retired to the stone mine connecting the Ell and Main coal seams. Into the side of this mine, where it was cut through solid rock, a bore hole, 4 feet deep, had been prepared to show, in case a blown out shot should by any means occur, whether any flame or sparks would be given off.

Where this hole was placed, it gave all the party a much better opportunity of watching the mouth of it. The charge used on this occasion was 3½ oz., and the hole was only partly stemmed, and that very loosely. When everything was ready, all the lamps were put under cover, so that the mine was in total darkness, and then the signal was given to fire; but in this instance the battery failed to act. The cable was therefore disconnected from the battery, and an examination made in perfect safety to find out what had gone wrong. It was at once discovered that one of the wires from the electric fuse had got disconnected from the cable. Probably the cable had been drawn up too tightly, and, the wire from the electric fuse not being properly connected, the connection had easily given way. The connection was made again, however, and the shot fired, when every one was satisfied that neither flame nor sparks were given off.

The party then returned to the surface, where several other experiments were shown to give further proof, if that were possible, that the gelatine-dynamite, when used with Settle's water cartridge, gave off neither sparks nor flame.

The first experiment was firing one of the water cartridges

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among a quantity of fine dry coal dust. Three ounces of gelatine was used. When fired, there was not the slightest appearance of flame or sparks, and the coal dust was thrown into the air, forming a dark cloud.

The next experiment was firing 1½ lbs. of powder, covered by a similar quantity of fine dry coal dust in the same way as the water cartridge. When the charge was fired, the coal dust was ignited, and the flame of it rose 20 feet into the air.

Still another experiment was tried. The water cartridge with 3oz. of gelatine was covered with 25lbs. of gunpowder; yet, when the charge was fired neither flame nor sparks were observed, and the loose gunpowder was scattered in every direction, without exploding.

Another shot with gunpowder was prepared, covered with coal dust, and part of the gunpowder scattered by the last shot. When it was fired the coal dust and powder were ignited, and the result was a very brilliant flame. This concluded the operations for the day.

Arrangements were made with the representatives of Nobel's Company for further experiments to be made in the solid workings of the Ell coal seam, and which were carried out on the 24th, 27th, and the 30th September, and the following are the particulars:—

The depth of the Ell coal from the surface is 117 fathoms.

SECTION OF SEAM.

Roof, Fakes and Ribs of Rock.

	Ft.	In.
Free Coal, ...	3	10
Splint Coal, ...	0	7
Free Coal, ...	0	7
Parting, ...	0	0
Free Coal, ...	2	3
	7	3

Pavement, Bastard Fireclay.

In the first place where the experiments were made on 24th September (Nicol's), the coal is wrought on end and very strong to blast down; the parting from the roof is not good. The place is 11ft. wide, and was holed 5½ft. in the right hand side, and 6ft. in the left; the holing was 2ft. 3in. high in the front,

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The right side of the place was leading by about a foot. Two holes were prepared, the right hand hole being 3ft. 8in. deep—9in. from the side, and 4in. from the roof; the left hand hole was 3ft. 11in. deep—1ft. 6in. from the side, and 4in. from the roof.

The coal is wrought in two carries—the upper, 5ft., being taken first—and it was in this part of the seam that all the experiments were made.

The left hand hole was charged and fired first. If powder had been the explosive, 14oz. would have been required, but in the water cartridge 3oz. of gelatine was used. The shot, when fired, was found to have been too light, for only the front of the coal was brought down. The coal was at once cleared back, and a man cut down the coal to the back of the hole so as to give the next shot a better chance.

In charging the next shot on the right hand side, 6oz. of gelatine was used, and when fired, the coal was brought down to the back of the hole. If powder had been used, 14oz. would have done the same work much better.

There was very little smoke made, but the fumes were slightly felt.

The next experiments were made in another part of the same section (Jack's place). It is 12ft. wide, and cross-cutting the coal. The place was holed an average depth of 5ft. 3in.; height of holing in front, 2ft. Two holes were bored in the coal—the one on the right being 3ft. 10in. deep, 9in. from the side, and 4in. from the roof; the hole in the left side was 3ft. 7in. deep, 12in. from the side, and 4in. from the roof.

The coal here is also very strong.

The hole on the right hand side was charged and fired first, and as the first shot in Nicol's place did not bring down the coal, this one was charged with 4½oz. of gelatine; but apparently the charge was still too light, for only about 10cwts. of coal was brought down. The coal left rent along the face was then taken down by one of the workmen, but still 6in. of the hole was left on. The left hole was then fired with the same charge, 4½oz., but in this case the coal was all brought down to the back of the hole. If these shots had been fired with powder, the first would have taken 14 and the second 12ounces.

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On the 27th inst. the experiments were continued in the same places.

Jack's place was holed 4ft. in the right hand side and 6ft. in the left. The right side was leading by fully 2 feet.

The left hand shot was fired first; the hole was 3 feet 10 inches, and charged with 3 oz. of gelatine instead of ¾lbs. powder. When fired only about 25 cwts. of coals were displaced; 13 inches of the hole was left on; this was a cut shot.

The right hand hole was bored 3 feet 6 inches and charged with 4½ oz., but when fired no coal was broken down at all although part was rent away; this hole was re-charged with 6 ounces of gelatine, which was not enclosed in a water cartridge, and when fired brought down the coal the length of the hole; the coal in this case was much broken.

When this shot was fired a spark was seen.

The next experiment was made in Nicol's place which was holed 6 feet; the holes were bored 3 feet 10 inches. Had powder been used 14 oz. for the first or bursting shot and 8 oz. for the second or cut shot would have been required.

The left hand side was fired first with 3 oz. of gelatine, but 14 inches of the hole was left on; the coals brought down were small, but a foul back was running parallel to the hole.

The right hand hole was charged with 6 oz. of gelatine, but without a water cartridge. Before this shot was fired the workmen had cut to the back of the first hole so that it had every chance to bring down all the coal, but when fired 12 inches of the hole was left on, but apparently the coal was loose and would work off to the back of the hole.

When this shot was fired a spark was observed, but it must be noted that no water cartridge was used. The experiments on the 27th were witnessed by Messrs Beith, Blyth, and Hastie, and in course of conversation it was suggested that if the shot-holes were bored 5 feet instead of 4 it might give the water cartridge a better chance of bringing down the coal. Instructions were therefore given to prepare two holes and bore them 5 feet for the 30th September.

The holes were prepared in Jack's place, the right side of which was holed in 4 feet 11 inches, and the left side 5 feet 2 inches;

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height of holing in front, 2 feet 3 inches. The left hole was charged first with 6 oz. of gelatine; the right side of the place was 18 inches in advance of the left. This shot when fired brought down the half of the coal, leaving coal rent along the face. When the rent coal was taken down it was found that 3 inches of the bore hole was left on. This was considered by those present the best shot that had been fired. The right hand shot was then prepared, the charge being also 6 oz. of gelatine, and when fired brought down the coal to within 11 inches of the back of the hole.

It may be noted here that all the holes were bored with an ordinary boring ratchet, and although the hole is larger than the one prepared for powder, yet it was not considered that any extra labour was taken in the boring owing to the boring ratchet being used instead of the ordinary jumper or kirner.

Cost.—The gelatine-dynamite cartridges are made as follows:—3″ × $\frac{7}{8}$″, 5″ × 1″, and cost 1s 8d (since reduced to 1s 7d) per lb. The Company say that 2$\frac{1}{2}$ oz. are equal to 1 lb. of gunpowder.

	per 100.	per 1000.
The Electric detonator fuse, with 54 inch wires cost each, ...	2·4d	2·16d
Water cartridge cases,...	1·0d	0·72d
Cartridge supports, ...	0·3d	0·24d
Total fixed charge for each shot, if bought in 100 lots is 3·7 pence; if bought in 1000 lots, 3·12 pence, ...	3·7d	3·12d
Magneto exploders cost, ...	£2 12 6	
50 yards cable, ...	0 12 6	
Fuse protector, ...	0 5 0	

Gunpowder in barrels costs 3$\frac{1}{2}$ pence, and in cartridges 4·2 pence per pound.

The above particulars are given so that members can make their own calculations to suit their own circumstances, but it will be seen at a glance that the blasting with water cartridges in the foregoing experiments is much more expensive than with powder.

Safety.—The very stringent test to which the water cartridge has been put affords conclusive proof of the absolute safety of this system of blasting, and no doubt it will be readily adopted where

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it would be dangerous to blast with gunpowder. In cases also where shots are heavily powdered, say from 3 to 5 lbs. blasting with gelatine would be a great relief to the workmen, as the air currents would not be loaded to anything like the same extent with smoke, and the fumes are almost nil.

So far as the experiments already recorded prove, it must be admitted that the gelatine used was very much in excess of the powder required if we accept the statement that $2\frac{1}{2}$ ounces are equal to 1 lb. of powder: and it is well known that the powder would have done its work much better, for in only three of the coal shots was the coal brought down to the back of the hole, and without a doubt if powder had been used as the explosive, the coals brought down would have been much rounder.

The discussion was adjourned and Mr Gilchrist was accorded a hearty vote of thanks for his paper.

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THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

11th NOVEMBER, 1886.

JAMES S. DIXON, Esq., President, in the Chair.

About 50 members were present.

The Minutes of the last General Meeting were read by the Secretary and confirmed.

The following, who had been duly nominated, were elected by ballot as Ordinary Members:—

GEORGE BLAKE WALKER, Tankersley Grange, Barnsley.
WILLIAM GIBSON, Ayr Colliery, Annbank.
NEIL MUNRO, Twechar, Kilsyth.
JAMES GOLDIE, Barncluith Colliery, Hamilton.
WILLIAM WATSON, Bank Street, Coatbridge.
GEORGE MIDDLETON, Westburn Colliery, Cambuslang.

The following discussions then took place:—

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DISCUSSION OF MR BURNETT'S PAPER ON BURNETT'S ROLLER MINING WEDGE AND DRILLING MACHINES.

THE PRESIDENT said, with reference to the proposed trials at Hamilton Palace Colliery, that nothing further had been done. He had not had any further communication from Mr Burnett. He proposed that they should close the discussion, and if the trials were made the subject could be reopened. He proposed a vote of thanks to Mr Burnett, the committee who took charge of the experiments, and to Mr Hastie, who was more immediately connected with them, for all the information they had laid before them.

This was cordially agreed to.

DISCUSSION OF MR GEMMELL'S PAPER ON "THE WORK OF THE ROYAL COMMISSION ON ACCIDENTS IN MINES."

The SECRETARY said this was a paper on which a very great deal indeed might be said if all the subjects referred to were gone into with any minuteness; but he suspected it embraced so many subjects that one felt not very much disposed to enter into anything like a full discussion of it. He thought it was valuable as presenting a most interesting abstract of the Commissioners' Report—a handbook indeed on the subject, and very suitable for being put into the hands of mining students.

Mr JAMES SMART said Mr Gemmell had certainly given them a very concise statement of the Report of the Commissioners. He did not know whether they were in a position to criticise that report or not. There was no doubt it was one of the most complete that had ever been laid before the British mining public. It dealt with all the dangers to which mining was subject; and by an elaborate series of experiments, which are minutely detailed and tabulated, shewed how explosions are so very much increased in force in mines where coal dust has accumulated. Such practical lists would be very useful to them in the future. The first point to which attention was directed was the

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accidents from falls of roof and sides, which embraced by far the largest proportion of mining accidents, but they did not seem to add any practical solution further than was known of before. In their report, as far as he recollected, the Commissioners recommended that the greatest care and attention should be given to this matter; and there was one point to which they drew particular attention, viz., that the miners should be educated as to the setting of props. This, he thought, a most useful hint, which they ought to look to, as not only the setting of props, but general instruction in all other branches of mining, would not only be conducive to their own safety, but would be of considerable benefit to their employers. In that case they would get better coal and less dross. Their mines were far too accessible to any labourer who chose to go into them. This was not what should be: the men should be educated as to the proper methods of working. Year by year they found the quality of the work deteriorating, and so far as his experience went, the percentage of dross was steadily increasing. The Commissioners' experiments in the way of exploding gas were very valuable; and, with regard to shot firing, he was struck with a clause in the New Mines' Bill, viz., where fire had existed within the last three months there was to be no person present when shots were being fired. Now, at a meeting of Mines' Inspectors a motion had been brought forward to this effect, and by a large majority it was considered that the 8th General Rule now in force was quite sufficient if it was walked up to. He was glad to see that the Commissioners seconded that decision of the Inspectors, because his own impression was that it would be a great hardship whenever a shot was to be fired that they should have to clear the pit. They knew there was a danger attending shot-firing, but there was a danger attending almost every step in mining, just as there was a danger in firing a gun. He thought the Commissioners had given a very fair report. They did not draw any hard and fast line. The principle that was generally laid down was, that greater caution should be exercised in everything, as it was for the masters' interest as well as for the safety of the men that such caution was to be exercised. He thought they were much indebted to Mr Gemmell for laying the matter so clearly before them.

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Mr F. J. ROWAN, referring to Mr Aitken's remarks at p. 156 of the Transactions, said that at the time Mr Aitken spoke he knew that experiments had been made to determine the effect of carbonic acid gas in an explosive mixture, but not wishing to say anything without referring to the authorities, he had not noticed these remarks at the last meeting. He was now able to refer to the experiments of MM. Mallard and Le Chatelier, whose names were mentioned in the Royal Commissioners' Report. They had found that the addition of a large quantity of carbonic acid gas to the explosive mixture elevated the temperature of a mixture of CO and O from 655° to 700° Cent. Carbonic acid gas acts very much as nitrogen does—perhaps a little more forcibly—elevating the temperature, and therefore rendering an explosion more difficult; and they arrived gradually at a point at which the carbonic oxide which was present in the mixture would not ignite at all. Mr Aitken also made a remark which, he thought, ought to be questioned, viz., as to the practical value of any of the fire-damp indicators mentioned in the Royal Commissioners' Report. He thought, in the face of the Report itself, and the experiments shown by Mr Gemmell, that Mr Aitken's remark was certainly open to question. Although some of those instruments which had been very clearly described—and not only described, but the principles of their action explained—by Mr Gemmell, might be too slow in their action for mining operations, one of them ought to be excepted, viz., the indicator of Mr Liveing. It seemed to him, speaking as one outside, that the action of that indicator was somewhat similar to that of a safety lamp as a detector of fire-damp, only more distinct. He could not see any objection that could be raised to the action of Liveing's indicator that would not equally apply to using a safety lamp. There was one objection, viz., that it did not indicate choke-damp, but he had no doubt some other means of indicating choke-damp would be found, and he just wished to say that he, for one, speaking entirely from a theoretical point of view, because he was not practically conversant with mining difficulties, felt disposed to join issue with Mr Henry Aitken as to his remarks about that indicator especially. Before sitting down, he wished to remark as to Mr Gemmell's paper that he was struck

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with the beautifully concise way in which the scientific part of the Commissioners' work was therein set forth. He did not think they would find anywhere a more clear and concise description of the action of spontaneous combustion, as it was called, in print, than they had in Mr Gemmell's paper—(cheers)—and the part explaining the action of those various indicators, and the principles on which they were founded, he did not think could be improved in any way.

The discussion was then closed, and, on the motion of the PRESIDENT, a hearty vote of thanks was given to Mr Gemmell.

Mr Gemmell afterwards communicated the following:—

Mr GEMMELL said there seemed to be a general feeling that the Commissioners had not been decided enough in their conclusions. Among others, Mr Dunn thought that they should have laid down a general rule as to how much ventilation should be produced in every mine. The Commissioners did consider whether it would be judicious to introduce such a standard, and came to the conclusion that, owing to the varying conditions of mines in this country, no fixed rule would be applicable. If we consider a crop mine, employing 50 men and raising say 100 tons of coal per day, probably 100 cubic feet per man per minute, or 50 cubic feet per minute for each ton raised daily, that is, 5000 feet altogether, would be sufficient ventilation. On the other hand, if we consider a new winning in a fiery district which has reached that stage in its development in which it also employs 50 men and raises 100 tons per day, who would in this case say that 5000 feet is sufficient ventilation? Probably eight or ten times that quantity would be required. He submitted a consideration of this kind amply justifies the wisdom of the conclusion to which the Commissioners came.

Mr Dunn seemed to think if sufficient ventilation was produced there would be no need of safety lamps. The evidence given before this Commission abundantly shows that there are many mines subject to periodical influxes of gas, with which no possible ventilation could cope.

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Mr Aitken said that indicators, particularly those of the platinum class, were unreliable; Mr Begg, in his paper on the Coal Mines Regulation Bill, calls them "instrumental curiosities;" and, if he remembered aright, Mr President said of them that they were "mere toys." He had the misfortune to disagree. No doubt there are many forms of so-called indicators, of the density and diffusion types, which are unreliable, and it was probably of these the President and Mr Begg were thinking when they used the language he ascribed to them. The Commissioners report that the platinum forms *were* reliable, and proved that they were capable of detecting the presence of such small quantities of gas in the air as $\frac{1}{4}$ or $\frac{1}{2}$ per cent.; and they found that Liveing's instrument could be practically employed in the daily examination of a mine. Mr Aitken went further. He asked what would be the effect of carbonic acid on the indications furnished by these instruments. Now, although the Commission discussed the effect of both this and moisture on some instruments that were manifestly inapplicable, they did not consider what influence carbonic acid would exert on platinum indicators. The addition of $1\frac{1}{2}$ per cent. of carbonic acid is sufficient to render inexplosive, air containing 6 per cent. of fire-damp. Such a mixture would contain 18 per cent. of oxygen, which is more than sufficient for the complete combustion of the 6 per cent. of fire-damp which it contains, consequently instruments of the Maurice class, which indicate the presence of gas by the contraction after combustion, would show 6 per cent. of fire-damp, and would not be affected by the presence of carbonic acid at all. Such a result would be on the safe side. It is not so clear, however, what would be the effect of carbonic acid on the brilliancy of the exposed wire in Liveing's instrument, and he thought, although he was speaking in defence of the Commission, that Mr Aitken had drawn attention to a point which the Commissioners ought not to have overlooked, viz., the influence of carbonic acid and moisture in the air of a mine on the light emitted from a glowing platinum wire: the experimental testing of the instrument was certainly not complete until that had been determined. Mr Aitken also revived the question as to the effect of carbonic acid in preventing explosions. He had been authoritatively

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taught to believe that when an explosive mixture is "damped" or masked by the presence of carbonic acid the addition of fresh air will render it again explosive. Of that he was sceptical When fresh air is added, no doubt the percentages of carbonic acid and fire-damp decrease, but they decrease in exactly the same proportion—that is to say, if 2 per cent. of carbonic acid masks the effect of say 12 per cent. of fire-damp, why should not 1 per cent. of carbonic acid be sufficient to "damp" the air containing 6 per cent. of fire-damp. From *a priori* reasoning, it seems impossible to show that the addition of fresh air to a "damped" mixture will render it explosive. Experiments might prove it otherwise, but unless they were carried out on a sufficiently large scale they would be unsatisfactory, as the cooling effect of the walls of small vessels on the gases which they contain materially interferes with the results.

Mr Faulds thought the Commission should have stated what was the best lamp, and have laid down hard and fast lines. They examined 250 lamps and selected four as the best. The laying down of fixed rules would, no doubt, relieve those engaged in mining of some responsibility, and, however good a thing that might be for colliery managers, the Commissioners were probably far-seeing enough to observe that the removal of responsibility from those in charge of mines was not likely to be followed by a decrease in the number of accidents.

Mr Beith asked a question as to the best means of laying dust. Perhaps the method he mentions of carrying the water in pipes and discharging it into the air in the form of fine spray is the most practicable. Attempts have been made to saturate the air at the downcast, and, although this may be to some extent beneficial in mines which are cool and not very dusty, it is manifest that in hot mines the rise in temperature will enable the air to take up moisture, and consequently cause dust. The only efficient way to neutralize coal dust is to use electric lamps and water cartridges, both of which are before this Institute. Mining is apparently on the eve of a revolution, to which he thought it would be admitted the work of this Commission has contributed in no mean degree.

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DISCUSSION OF MR M'KINLESS'S PAPER ON "A GAUZELESS SAFETY LAMP."

Mr ROBERT BEITH said since the committee proposed at last meeting was appointed they had met twice, and had before them from eight different manufacturers 146 lamps, including six of Mr M'Kinless's. The committee were busy working out experiments, so as to find the best substitute for the Scotch gauze lamp, and it was premature to give in anything like a report at this meeting. They wished to examine the whole of them practically. With reference to what Mr M'Kinless said at last meeting as to the new oil he had got, he had tried it, and it was certainly a great improvement. The lamp burned a good deal more clearly and for a longer time without trimming.

Mr M'KINLESS said that having been in Edinburgh, he had just discovered that the six lamps sent to Mr Beith were of the old type. There had been a little alteration made on the lamps. He had discovered that in certain conditions the lamp would sulk, and that had been remedied by drilling another row of holes in the band that protects the inlet holes. He had also made another little alteration to suit a firm in the neighbourhood of Wigan who had been making experiments for some time. They had erected an apparatus for testing lamps. They had had every modern lamp under trial, and he was pleased to tell them his had come off A1. Mr M'Kinless here produced and explained his perfected lamp.

Mr BEITH asked if Mr M'Kinless made any alteration on the height of the burner.

Mr M'KINLESS answered in the negative, and said with the new oil there would be no difficulty on this score. Moreover, with a different wick, which he recommended, they would get better results than with the old one. He had made the wick tube wider and so made use of a paraffin wick.

Mr HASTIE asked how the lamp would act in a body of gas.

Mr M'KINLESS—It will go out.

Mr BEITH—Did ever you see that?

Mr HASTIE—We made a few trials and found it burned up along the sides.

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Mr M'KINLESS—You mean the flame would rise considerably?

Mr HASTIE—After the flame was out, the gas burned inside. The gas burned for a few seconds.

Mr M'KINLESS—It is bound to go out.

Mr GILCHRIST said he thought Mr M'Kinless might still make some improvements as far as light was concerned. The light being so near the chimney was very much against it. In carrying the lamp one morning burning the ordinary colza oil—not colzalene—the lamp went out twice, while a Protector Mueseler he was carrying did not go out. As to the shield, he did not think it was of very much benefit. In fact, he would not be at all surprised if it were condemned. So far as his experiments went, they might have gas burning inside, and the man would readily imagine that his light was out. That was, if they were in an atmosphere of gas, the gas was burning inside and they did not see it. If Mr M'Kinless would just try and by careful experiments test that point he would do a service. He had no doubt he would yet make it a good lamp.

Mr M'KINLESS said he had ascertained that there were conditions under which the lamp would continue to burn inside for some time.

Mr GILCHRIST—What are the conditions?

Mr M'KINLESS—Certain mixtures of the gas and air. In the Aldwarke Main experiments, they suspected the possibility of gas burning where it could not be seen, and to test that they allowed the apparatus to run out. After the flame had gone out, it was found the current of air during the time it had lasted had made the lamp quite cool which was fair proof that there was no gas burning inside. In any case supposing any quantity of gas ignited inside, although it burned for a week they could not make the lamp red hot.

Mr GILCHRIST said it was just possible that most of the experiments might have been tried with a very sharp current of air. The most of the experiments he had seen recorded had indeed been in an exceedingly quick current of air; but if tried where there was very little air, he had an idea that a lamp which was perfectly safe in a quick current would not be so in a quiet

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current. There were parts of the best ventilated collieries where there was not much air, and there might be some danger from men going into such places with this lamp.

The PRESIDENT said within the last hour and a half he had seen some experiments tried which rather astonished him. In the Marsaut lamp, recommended by the Royal Commissioners, the gas was found to be burning inside while the lamp was out, but on account of the shield was not seen to be burning. With such a lamp, a man might be in great peril and imagine he was in darkness. At Bent Colliery, their oversmen had tried Mr M'Kinless's lamp, and their report was that the lamp went out almost as easily as the Protector, that it was a very hot lamp, and required very frequent trimming. He asked them to give a candid opinion, and that was what they reported. He thought the committee they had appointed was a step in the right direction. What he had stated showed that in all those careful experiments by the Royal Commissioners they had overlooked a very simple but dangerous state of matters. They had been trying to meet the danger arising from gas at a high velocity and had apparently not thought of the danger inside a lamp which was among still gas. Really they had a great deal to learn yet. He supposed that a number of them had read the valuable book on explosions recently issued by Messrs Atkinson. That was a report which threw a new flood of light on this question. They had been struggling to get a lamp to protect them from gas, and in that book the authors made out that they were not struggling with the proper enemy, which was coal dust. It seemed to him there was not half the danger connected with an explosion of gas as with an explosion of dust. Gas might initiate the explosion and burn a man or two, but that initiation might with dust cause a fire for miles, and it was that they had to struggle against.

Mr GILCHRIST, with reference to the shut-off appliance recommended by the Commissioners, said a man going into gas suddenly would very likely lose his light, and would not think it necessary to shut off the air; and if the lamp were kept in the gas, the gas inside the gauze would burn away until the lamp was removed.

Mr BEITH remarked that these lamps with shields, with the

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shut-off appliances, got very hot after burning a few hours, and when the shut-off appliances were fixed on the top of the shields they got so warm that they could scarcely be used. He asked Mr M'Kinless to forward to the committee six of the improved lamps to take the place of the six they had.

Mr J. T. ROBSON said Mr Beith's objection to the shut-off could only apply if it was at the top. If at the bottom it could not.

Mr BEITH—Some are on the top and some on the bottom.

Mr HASTIE said he travelled the roads for five hours with this lamp and did not find it hot. He brought it up the downcast shaft and it did not go out. He had done the same with the Protector and it went out. It was burning colzalene, and he thought it could be carried about as well as the Mueseler.

Mr M'KINLESS—The point of heat was discussed at a meeting in Lancashire, and there were witnesses who said it was not nearly so hot as the Mueseler.

Mr HASTIE said he really thought a man was in a good deal of danger with the shield.

Mr M'KINLESS—It is not a question of safety but of convenience. It would be perfectly safe without it.

The PRESIDENT, in closing the discussion, expressed the hope that Mr M'Kinless would forward to the committee some of his improved lamps so that they might test them properly. He said he might add that in the experiments made in gas he thought Mr M'Kinless's lamp behaved very creditably. It went out at once.

Mr M'KINLESS said he would be glad to send another half-dozen lamps in place of those in the hands of the committee.

A hearty vote of thanks, on the motion of the PRESIDENT, was tendered to Mr M'Kinless.

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DISCUSSION OF MR JAMES GILCHRIST'S PAPER: "NOTES ON EXPERIMENTS WITH SETTLE'S PATENT GELATINE WATER-CARTRIDGE AT EARNOCK COLLIERY."

The PRESIDENT said since last meeting some experiments had taken place at Bog Colliery with the Water Cartridge. He invited Mr Grant to give the results.

Mr JOHN GRANT, who did not expect to be called upon, promised some notes, which it was agreed should be printed as part of the discussion.

Mr JAMES GILCHRIST said since last meeting the battery on the table for firing the cartridges was forwarded to him. Those shewn at last meeting were not what were recommended, and this one, which was expected at that time, came a day too late. In experimenting with the battery, he was rather astonished to find that with a very short cable he could light the gas with it. Some of Nobel's people had also tried experiments with the same result. However, they found that with a cable of 30 yards in length this could not be done, and further experiments he had made with a longer cable confirmed this result. But still it was a fact that they had an instrument there with which they could ignite gas. The electro-motive force was very low, viz., 1·20. Seeing that at the experiments at Earnock there was always part of the coal left on, it occurred to him that if half an inch of water was sufficient round the gelatine cartridge, would not an inch at the back side be sufficient, and so give the charge a much better chance of bringing down all the coal?

Mr JAMES HASTIE said from the time they were at Earnock the cartridges had not improved much. He did not know if they did as well.

Mr J. T. ROBSON said it seemed as if they required a certain quantity of water, and if it were not at the sides, it must be at the back or front.

The PRESIDENT, said they could by experiment see if it would not do further back. If so, it would obviate the difficulty.

Mr THOMAS ARNOTT said Mr Bonser told him that they could go back as far as they liked if they kept water behind it.

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Mr CONNAL, referring to the statement on p. 179 that the gelatine would be a relief to the workmen, said he would like if possible to ascertain the effects of the fumes. By sad experience on Lochfyneside the poisonous nature of the fumes of gunpowder were known. It might be useful to ascertain that of the gelatine as it might be one of its recommendations.

Mr GILCHRIST pointed out that at p. 173, it was explained that as regarded the first shot very little smoke was given off; and, a little further down, with reference to the second shot, that smoke was given off and had a slight smell, but was not as bad as if powder had been used.

Mr DAVID JOHNSTON said the question was whether the gas, though unseen, might not be destructive. The gas at the Lochfyneside accident was not visible.

Mr. F. J. ROWAN said the products of the explosion and combustion of nitro-glycerine were both poisonous and invisible; perhaps more so than the products of the combustion of gunpowder, but the quantity of the explosive used was so much less than that of gunpowder to do the same amount of work that the quantity of gas set free was of course very much less. He did not remember the exact analysis of the products, but he had seen it in three or four different papers. He thought one was by Mr M'Roberts in the transactions of the Philosophical Society of Glasgow. At any rate it was given in a paper by Sir Frederick Abel. As to the quantity of water in the cartridge, very likely—in fact, certainly—a great part of the rôle which the water had to play was to prevent the effects of a too rapid explosion of the blasting gelatine. Those high explosives acted so rapidly that their effect was to pound the mineral to powder in their immediate neighbourhood. He had no doubt the question of the position of the cartridge in the tube would be met by a reason of that sort. It was not merely to extinguish the flame, but also to regulate the action of the explosive producing that quality of explosion which was required for putting out the coal in a proper way without pounding it to powder.

Mr JAMES SMART said he would expect the water in the cartridge would consume some of the smoke and prevent the smoke from rising.

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Mr ROWAN said, unfortunately for this theory, it did not exist as water any longer. It was formed into steam by the heat of the explosion.

The PRESIDENT said he had not the slightest doubt but that Mr Rowan's explanation of the water behind the cartridge in the tube was the correct one. The water was there as a cushion to prevent the cartridge rending the coal so rapidly; but it was a matter for experiment whether it would make any difference to have the cartridge further back. It would be a great advantage if they could bring down the whole of the coal. If equally safe, which should be found out, those who adopted it would soon find out whether it did any material damage to the coal.

Mr FAULDS said he believed from what had been said the water in this case made it less deleterious to health. He thought there were members who had great experience in working without water, and in charging with too much dynamite, the combustion that followed was very injurious, particularly to the head.

Mr ROWAN said it was well-known that that was the effect of the fumes from dynamite, and also it produced bleeding from the nose. He had known tunnelling work where the men had to leave off work from the bleeding of the nose brought on by these fumes.

Mr J. T. ROBSON said he believed it was quite true that amongst miners there was a feeling that it was deleterious. They got headaches by it, but might not that be because they were unaccustomed to it, while they were so accustomed to gunpowder they never felt it? As to gelatine, he thought there could be no doubt the quantity of fumes was considerably less than with a charge of powder.

Mr ROBERT BEITH, in reference to the use of dynamite, said he had had considerable experience, and he had found that at first when they commenced to handle the cartridges, and if they happened to put their hands to their head, a headache was the result, but when they got accustomed to it, and got into the system of balancing their shots while charging, it had no dangerous effects. It was better for metalliferous mines than gunpowder, although when a hole was heavily charged, the fumes were considerable, and took some time to clear away.

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Mr ROBERT M'LAREN said, at the experiments at Bog he went in, and he felt less effects from combustion by the gelatine than from gunpowder. In fact, in some cases, he scarcely felt any effects at all.

Mr GILCHRIST said that was one of the conditions he paid particular attention to. He had also done some work with dynamite, and could assure them that, so far as he saw the gelatine, it was much more pleasant to work with. As to the overcharging of holes, there was no question no matter what explosive they used, even gunpowder, if they overcharged it, the fumes were very bad.

Mr ROWAN said the fumes from an explosive substance when burned slowly were of a different quality from those obtained when it was exploded.

The PRESIDENT said there was one practical answer: those cartridges were so small that if exploded in a reasonable current of air they could not contaminate it to any extent, although, if used extensively, as in some ironstone pits he had had the misfortune to be in, they might be deleterious.

The discussion was then adjourned till next meeting.

Mr JOHN GRANT afterwards communicated the following:—

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NOTES ON EXPERIMENTS WITH SETTLE'S PATENT GELATINE WATER CARTRIDGE AT BOG COLLIERY.

By JOHN GRANT.

A NUMBER of gentlemen were invited, and fully thirty came forward. The experiments on Thursday, 28th October, were made in the Main and Splint coal seams, which are worked stoop and room. The depth from surface to the Main coal seam is 85 fathoms; to the Splint seam, 100 fathoms. The first experiment was made in two close places in the Main coal seam, about 240 yards from the shaft; the next place was to the rise, about 400 yards from the shaft. Here a place was prepared on the side of a stoop, 21 feet in length; three holes were drilled, but it was thought unnecessary to charge the third, two only being fired.

The following is a section of the Main coal seam, and a table shewing the results of the experiments :—

SECTION OF MAIN COAL.

		Ft.	In.
Rock Roof.			
	Free Coal, ...	1	1
	Splint ,, ...	0	3
	Free ,, ...	1	0
	Coal Sclit, ...	0	1½
	Free Coal, ...	0	10½
	Splint ,, ...	0	6
	Free ,, ...	0	10
Pavement, Bastard Fireclay.			
		4	8

RESULTS OF EXPERIMENTS IN MAIN COAL SEAM.

Number of Holes.	Width of Places.	Height of Coal.	Depth of Holing.	Height of Holing in Front.	Diameter of Hole.	Length of Hole.	Distance from Fast Side.	Distance from Roof.	Ounces of Gelatine Dynamite.	Powder to do the same work.	Length of Hole left on.	Coal brought down.	Coal Cleaned off by Miner.
	Ft.	Ft. In.	Ft. In.	Ft. In.	In.	Ft. In.	Ft. In.	Ft. In.	Oz.		Ft. In.	Tons. Cwt.	Tons. Cwt.
1	11	4 8	5 2	1 3	2½	4 6	1 0	1 0	4	¼ lb.	1 0	0 10	6 0
2	11	4 8	5 2	1 3	2½	4 6	1 0	1 0	4	7 oz.	1 0	0 15	
3	11	4 8	5 3	1 3	2½	4 3	1 0	1 0	4	¼ lb.	0 9	0 15	6 10
4	11	4 8	5 3	1 3	2½	4 6	1 0	1 0	4	7 oz.	0 6	1 0	
5	21	4 8	5 0	1 0	2½	4 3	1 6	1 0	4	7 oz.	0 9	1 0	12 10
6	21	4 8	5 0	1 0	2½	4 3	8 6	1 0	8	6 oz.	0 2	3 0	

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The party now returned to the pit-bottom, where a bore hole 5 feet deep had been prepared in the centre of a road to show a "gunner," to see if any flame or sparks would be given off. The party had a good opportunity of seeing the mouth of hole. The charge used was five ounces, the hole being loosely stemmed. When everything was ready, all lamps were put out or covered, the place being in total darkness; the signal was given to fire, and when the explosion took place every one was satisfied that neither flame nor sparks were given off. The party then descended to the Splint coal seam, when they were conveyed in hutches by endless rope near to the place, about 1200 yards distant. Here two places were prepared, but seeing the time was so far advanced, only one place was taken.

The following is a section of the Splint coal seam, and a table shewing the results of the experiments:—

SECTION OF SPLINT COAL.

		Ft.	In.
Rock Roof.			
	Falling Fakey Slate, ...	0	2
	Free Coal, ...	0	8
	Splint ,, ...	1	7
	Gas ,, ...	0	10
	Free ,, ...	0	6
	Splint ,, ...	0	6
	Free ,, ...	0	9
Pavement, Firelay.			
		5	0

RESULTS OF EXPERIMENTS IN SPLINT COAL SEAM.

Number of Holes.	Width of Places.	Height of Coal.	Depth of Holing.	Height of Holing in Front.	Diameter of Hole.	Length of Hole.	Distance from Fast Side.	Distance from Roof.	Ounces of Gelatine Dynamite.	Powder to do the same work.	Length of Hole left on.	Coal brought down.	Coal Cleared off by Miner.
	Ft. In	Ft. In.	Ft. In.	Ft. In.	In.	Ft. In.	Ft. In.	Ft. In.	Oz.	Lb.	Ft. In.	Tons. Cwt.	Tons. Cwt.
1	10 6	4 10	5 2	1 3	2½	4 3	0 9	0 10	4½	¼	0 6	0 15	7 10
2	10 6	4 10	5 2	1 3	2½	4 3	0 9	0 10	4	¼	..	2 10	

The party then returned to the surface, where other experiments were shown. The first was the firing of one of the water

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cartridges in a quantity of fine, dry coal dust. Three ounces of gelatine were used; when fired, there was no appearance of flame or spark, the coal dust being thrown in the air.

The next experiment was firing 1½ lbs. of gunpowder, covered by a similar quantity of fine, dry coal dust, in the same way as the water cartridge. When the charge was fired, the coal dust was ignited, and the flame of it rose a considerable height in the air.

No notice has been taken in these experiments of the appliances required for blasting, as they are fully explained by Mr Gilchrist in his paper. After seeing the stringent test to which the water cartridge was subjected, I think I can endorse what Mr Gilchrist has said as to the absolute safety of blasting with it when it would be dangerous to blast with gunpowder. In places where so much powder is used,—such as in shale workings,—the gelatine would be of great advantage to the workmen. There is very little smoke, and the fumes are very slight. There is no doubt the coal brought down by powder is much rounder than that by gelatine dynamite.

The following description of a Self-Acting Brake for preventing overwinding was read by the Secretary:—

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SELF-ACTING BRAKE FOR PREVENTING OVER-WINDING.—Designed by Gilbert M'Pherson.

Communicated by Mr Robert L. Galloway.

The accompanying plan (Plate XVIII.) represents an arrangement of self-acting mechanism for arresting a winding-engine in the event of the cage being accidentally lifted so high as to be in danger of being drawn over the pulleys. Mr M'Pherson, the designer, is probably already known to some of the members as the inventor of various ingenious mining contrivances, among which may be mentioned a steam boring machine, a hutch greasing machine, safety gates for mid-workings, &c., which have been found of considerable practical utility. In the arrangement before us, as will be seen from the plan, a heavy weight is suspended from the lever of a brake on the drum or fly-wheel. Under ordinary circumstances this weight is prevented from operating on the brake by means of a trigger which acts as a support to it. But when the cage is unduly raised it will strike a rod placed over the pit, and, in so doing, draw the trigger and allow the weight to act upon the brake, thus quickly arresting the engine.

DISCUSSION.

Mr Robert Beith said he thought the apparatus would suit very well. He had seen instances of cages being drawn up to the pulleys by mistake instead of being let down. In that case this appliance would do well. If the engineman was neglecting his duty and the steam was not shut off, he did not know if the brake would hold the cage. Perhaps, if by some contrivance it was connected with the throttle valve, so as to shut off the steam, it would act much better.

The President said he once saw an engine so designed that the bottomer in belling away the cage turned on steam. There was no engineman; but it was like a great many other schemes it had to be abandoned. The next time he went there was an engineman.

The discussion of the paper was adjourned.

The following paper on "A Miner's Electric Safety Lamp" was read by Mr David Reid:—

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A MINER'S ELECTRIC SAFETY LAMP.

By James Pitkin.

The subject of this paper is one which should interest us all. It is one which concerns the very life of the miner, and it also touches on the convenience and comfort of all who are engaged in mining operations.

The one great want of the miner is *better light*—something to supersede the dim, feeble light of the small oil lamp, which does little more than render the darkness visible.

If we search for the means of giving this greater light with safety, our only method of getting it is by electricity. If we employ this agent for that purpose, even the very black mass the miner is working amongst can be subordinated to his use.

Some few years ago, in reading the "Times" newspaper, the writer was, like the rest of the world, astonished at Sir William Thomson's account of Faure's bottled up electricity; and all will remember the stir these wonderful accumulators made in all parts of Great Britain.

I need not say that I was greatly interested in this fascinating invention, and, having the means of experimenting on these batteries in my workshop, I have worked more or less at the subject since that time.

My immediate object was not to make a miner's lamp, but to do away with the weak points in the Faure battery, and to get a much larger percentage of active material on the lead plates without increasing their weight much; in fact, to increase their storage capacity and render them more durable.

However, the frequent occurrence of dreadful explosions, in which the demand for a better safety lamp arose, turned my attention to the subject, to try if I could make my batteries available for that purpose. After much experimenting and many disappointments, I at length produced the lamp which is now before you.

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The lamp, with the white enamel reflector, has three cells with eleven plates in each. The cells are made of vulcanite, and are coated inside with a composition which I have found to render even wood impervious to acid. They are thus acid proof.

Pitkin's Electric Safety Lamp.

The lead plates are suspended from the vulcanite tops of each cell in rows—crossways of the cells, and connected up in series. They are then placed in a stout oaken case or box for protection, with sliding lid, and fixed in the boxes with a composition. The connections at the top of the cells are insulated from the action of the acid by the same composition that is used for the lining of the vulcanite cells. The plates or elements have a trough-like shape on each side, with lead pins projecting at intervals. Into these troughs is placed the storage material which has been carefully manipulated before being put into them. It soon becomes a hard mass, and there is no danger of its falling away from the plates, as the pins which are cast in them act as rivets in holding the active material to its work, and when carefully done there seems to be chemical adhesion between the plates and the storage

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material. There is no danger of the cells short-circuiting, unless they are partly emptied of acid and left some time in that condition.

I have had plates in use of a much larger size for many months, and they are better than the first day they were used.

The three-cell accumulator will give a light equal to about five candles, and will last from ten to twelve hours.

The four-cell accumulator with the bright reflector has only eight plates or elements in each cell, the arrangement being the same as in the three-cell battery.

The electro-motive force of each cell is 2·4 when first discharging, so I have put a resistance in each box with instructions how to use it. It is to economise the filament of the lamp. I need not say that it is a very durable little accumulator.

The stems of the plates which suspend them in the cells are very strong. The connections are carefully insulated from the acid, and with moderate care will not easily get out of order. You have already at every mine a steam engine which works the lift, and a dynamo at a moderate cost can be added to charge these lamps, and men can soon be trained to look after both.

You have here also a detachable lamp with three cells, which is very useful in railway travelling. The battery can be put under the seat, and the lamp placed in your button-hole by means of a hook which is fixed to the back of it, the connection being made by a silk cord and switches.

Such is a brief account of the circumstances which have led to the production of this lamp, and also of the lamp itself. If it is found that my humble efforts have resulted in a more serviceable and more desirable light for the work of the miner, I shall feel that I have not worked in vain, and this knowledge shall give me far greater satisfaction than any advantage it may bring me.

DISCUSSION.

The PRESIDENT said he really believed this was the solution of the light difficulty—perhaps not exactly in its present form; but now that it was before gentlemen conversant with electricity, it would ere long be perfected.

Mr ROBERT BEITH said he had had the lamp underground. It

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gave a splendid light. They had no idea how much superior it was even to the naked light. It also showed the roof clearly. He considered it a great improvement, and if Mr Reid or Mr Pitkin could manage to reduce the weight of the lamp, and if the cost was not too much, he thought it would be the lamp of the future.

Mr GILCHRIST said he did not think there could be any doubt but they had before them the lamp of the future. After carrying one of the lamps before them for a considerable time, he could assure them they required to see it underground before they could actually believe what the light was. At the working faces no number of safety lamps was equal to the light given by that little lamp. He did not think the weight (8 lbs.) an objection. A man could carry the lamp readily and hang it up, and so illuminate his working place. Along with Mr Beith, at Backmuir Colliery, in one of the working faces, he held it about 4½ feet high and 12 feet back in a 7 feet seam, and it illuminated the whole of the face, giving light to the roof as well as the pavement. Mr Reid would require to give them a great deal of information before they were done with him, and possibly Mr Pitkin might be able to furnish him with that before next meeting. He should give them an idea as to what horse-power would be required to charge say three hundred of these lamps, and the expense of fitting up a lamp cabin with electric wires for that purpose. He should also mention how they were charged. He took it that an arrangement could be made whereby when it was put into the charge room or lamp room they simply put it on the shelf; the two connections would fit in, and the lamp left charging until next morning, when the attendant would hand the miner a lamp fully charged.

The PRESIDENT asked if there was any liquid.

Mr REID said there was diluted sulphuric acid.

The SECRETARY—Mr Pitkin will not yet be able to indicate the price.

Mr REID—No, he has not come to that.

The SECRETARY—How long does the lamp burn?

Mr REID—Eight to ten hours.

Mr ROWAN asked what was the dimensions of the light after the first hour or two.

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Mr GILCHRIST said he had it burning for 8½ hours. For 2½ hours it burned with the resistance coil put in. After that he had on the full power, and the lamp gave way at the end of the 8½ hours, but at that time he could not say the light was diminished in any way.

Mr ROWAN—You did not measure the light?

Mr GILCHRIST replied in the negative. He asked Mr Reid if the dynamo they had at Earnock could be made serviceable for charging these lamps or would they require to get dynamos with much less resistance than these were?

Mr ROWAN said he could not understand the object of having a resistance coil through which the battery was to work at first, because it seemed to him to be using up the power of the battery unprofitably.

Mr REID—That is easily explained. We want to save the film of the lamp.

Mr ROWAN—What is the use of it when it is at the expense of the battery.

Mr Reid—The lamp is more expensive than running the dynamo.

The PRESIDENT suggested that in place of the ornamental oak case one of strong, plain construction should be made for an underground lamp.

Mr ROBERT STEWART pointed out if the light could be taken some distance by means of a six or ten feet length of wire, the miner could leave the heavy part in one place and use the light in another.

Mr GILCHRIST said he did not think that that would be of any service. They tried it at Earnock; they had an electric lamp made quite portable and with flexible wires so as to take the light into the face, but the workmen did not think anything of it, the wires behind being a greater trouble than benefit.

The PRESIDENT said it was a very interesting subject, and he hoped Mr Reid would come prepared to give them any information he could.

This concluded the proceedings.

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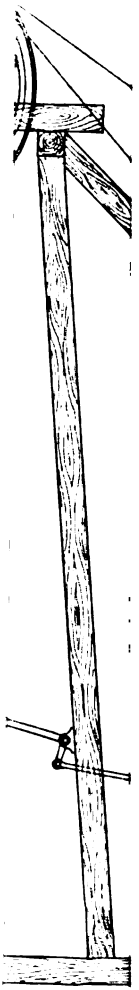

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THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,

23rd DECEMBER, 1886.

JAMES S. DIXON, Esq., President, in the Chair.

Fully 40 members were present.

The Minutes of the last General Meeting were read by the Secretary and confirmed.

The following, who had been duly nominated, were elected by ballot as Ordinary Members:—

JAMES M'KILLOP, Slamannan.
HUGH FINDLAY, Gartsherrie Colliery, Coatbridge.
DUGALD BAIRD, Raith Colliery, Cowdenbeath.

GLOSSARY OF SCOTCH MINING TERMS.

The PRESIDENT said that there had recently been sent to each of the members a copy of the Glossary of Scotch Mining Terms compiled by the Secretary, and he proposed a hearty vote of thanks to Mr Barrowman and those who had co-operated with him in the work, which was accorded.

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DISCUSSION OF MR G. B. BEGG'S PAPER ON THE COAL MINES REGULATION BILL, RECENTLY PUBLISHED.

The PRESIDENT said that as the Bill had been submitted to a Committee of the Institute to be criticised, he thought it would be better to close the discussion of Mr Begg's paper.

This was agreed to, and a vote of thanks was awarded to Mr Begg.

The SECRETARY then read the following Report by the Committee on the Mines Regulation Bill, 1886 :—

REPORT OF THE COMMITTEE ON THE COAL MINES REGULATION BILL.

IN furtherance of the discussion of Mr Begg's paper on the Bill for the Regulation of Coal Mines, introduced into last Parliament by Mr Childers and Mr Broadhurst, and as suggested at the general meeting of the Institute held on 30th September, 1886, the Council appointed a large and influential committee, the President, Mr James S. Dixon, convener, to consider the Bill and report.

Although the Bill was brought in by the late Government, and was therefore defunct, still the Committee had good reason to believe that a similar or identical measure will be brought in during the ensuing session of Parliament, and therefore that this is a most appropriate time for its discussion by the Mining Institute of Scotland, the members of which are nearly all actively engaged in practical mining. The Committee were guided by the desire that a really valuable and workable measure should be passed into law; and that clauses which are impracticable, and likely to lead to evasions, should be avoided; and that all vagueness in the wording of the Act should be made clear so that there can be only one interpretation of what is meant. The Committee in all their deliberations made safety their first consideration; but this should be accomplished in a practical manner, and so that in avoiding one danger others are not created or intensified. The Committee had five meetings, and carefully considered each clause of the Bill, and beg to report as follows, viz. :—

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Part I.

Clause 4.—No boy under the age of ten years, and no woman or girl of any age, shall be employed in or allowed to be for the purpose of employment in any mine to which this Act applies below ground.

It is the opinion of the Committee that, so far as Scotland is concerned, there is no necessity for boys of ten to twelve years of age being employed underground.

Clause 8.—With respect to women, girls, and boys employed above ground, in connexion with any mine to which this Act applies, the following provisions shall have effect:—

(1.) No child under the age of ten years shall be so employed:

(2.) No woman or girl, and no boy shall be employed for more than fifty-four hours in any one week, or more than ten hours in any one day, or between the hours of nine at night and five on the following morning, or after two o'clock on Saturday afternoon; and the regulations of the last preceding section shall apply to every woman, girl, or boy so employed.

(2.) In regard to employment of women, girls, or boys above-ground, the Committee consider that the words "or after two o'clock on Saturday afternoon" should be deleted. Such persons in their employment are fully protected in the previous part of the clause, as they are not to be employed for more than fifty-four hours in any one week, etc. It is found in practice, since picking and cleaning the coal on the surface has been so much resorted to, that this limitation of the hours of the boys so employed amounts to a compulsory limitation of the other work both above and underground; or, on the other hand, the practice is usually resorted to of starting work earlier on Saturday mornings to overcome the difficulty. The consequence is that a large proportion of the workpeople are inconvenienced, some of whom have in ordinary cases to be in the pits as early as four or five o'clock in the morning; and others, who reside at considerable distances from their work, are put to serious hardship, so as to allow the boys to stop work at two o'clock. The Committee recommend that these words be either deleted, or that a later hour, say four o'clock, should be substituted, and this would entail no hardship on the boys, especially as at many collieries work is not carried

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on for six days a week, so that in such cases the length of employment is much less than fifty-four hours per week. The closing sentence of this clause will also fall to be deleted. It is as follows :—

The provisions of this section as to the employment of women, girls, and boys after two o'clock on Saturday afternoon, shall not apply in the case of any mine in Ireland, so long as it is exempted by order of a Secretary of State.

Clause 10.—**If any person contravenes or fails to comply with, or permits any person to contravene or fail to comply with, any provision of this Act with respect to the employment of children, women, girls, or boys, or to the register of boys, women, and girls, or to the reporting the intended employment of boys, he shall be guilty of an offence against this Act; and in case of any such contravention or non-compliance by any person whomsoever, the owner, agent, and manager shall each be guilty of an offence against this Act, unless he prove that he had taken all reasonable means by publishing and to the best of his power enforcing the provisions of this Act to prevent such contravention or non-compliance.**

The Committee wish to point out that in this clause and throughout the Act, the owner, agent, and manager shall be guilty of an offence against the Act for its contravention by other persons, unless he prove that he had taken all reasonable means by publishing and to the best of his power enforcing the provisions of the Act to prevent such contravention or non-compliance. This is a reversion of a fundamental principle of our laws, that a person be considered innocent till he be proved guilty, and the Committee fail to see how owners, agents, and managers of mines should be so treated, and they would recommend that this clause, here and elsewhere in the Bill, should read as follows :— . . . . "and in case of any such contravention or non-compliance by any person whomsoever, the owner, agent, or manager shall be guilty of an offence against this Act, if he has not taken all reasonable means by publishing and to the best of his power enforcing the provisions of this Act to prevent such contravention or non-compliance."

Clause 13.—**The persons who are employed in a mine to which this Act applies, and are paid according to the weight of the mineral gotten by**

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them, may, at their own cost, station a person (in this Act referred to as "a check weigher") at the place appointed for the weighing of such mineral, in order to take an account of the weight thereof on behalf of the persons by whom he is so stationed. The check weigher shall have every facility afforded to him to take a correct account of the weighing for the persons by whom he is so stationed; and if at any mine proper facilities are not afforded to the check weigher as required by this section, the owner, agent, and manager of such mine shall each be guilty of an offence against this Act, unless he prove that he had taken all reasonable means by enforcing to the best of his power the provisions of this section to prevent such contravention or non-compliance.

The check weigher shall not be authorised in any way to impede or interrupt the working of the mine, or to interfere with the weighing, but shall be authorised only to take such account as aforesaid, and the absence of the check weigher shall not be a reason for interrupting or delaying such weighing.

If the owner, agent, or manager of the mine desires the removal of a check weigher on the ground that such check weigher has impeded or interrupted the working of the mine, or interfered with the weighing, or has otherwise misconducted himself to the detriment of the owner, agent, or manager, he may complain to any court of summary jurisdiction, who, if of opinion that the owner, agent, or manager shows sufficient primâ facie ground for the removal of such check weigher, shall call on the check weigher to show cause against his removal. On the hearing of the case the court shall hear the parties, and, if they think that at the hearing sufficient ground is shown by the owner, agent, or manager to justify the removal of the check weigher, shall make a summary order for his removal, and the check weigher shall thereupon be removed, but without prejudice to the stationing of another check weigher in his place.

The court may in every case make such order as to the costs of the proceedings as they think just.

It was the unanimous opinion of the Committee that modifications of this clause are absolutely necessary, so as to avoid the constant irritation that will arise from the working of it as it stands. As a rule, check weighers are not in constant employment, but it is found in practice, especially in times of wages agitations, that a few of the agitators among the men in a pit put on a check weigher whose ostensible duty is to check the weights, but in reality it is to act as a spy on the output and conduct of the men who would rather not be so interfered with. Such men are also made to contribute to the wages of the check weigher against their will. Check weighers in future, unless provision

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is made to avoid this, will most probably be nominees of the trades unions, and unless the conditions of their employment be strictly laid down, good feeling between employers and employed, which is so much to be desiderated, will be greatly endangered. The Committee propose that the third part of Clause 13 should be altered to read as follows, viz. :—"If the owner, agent, or manager of the mine desires the removal of a check weigher on the ground that such check weigher has impeded, interrupted, or interfered with the working of the mine, or in any way with the freedom of action of the workmen employed therein, or interfered with the weighing," etc., etc.; and at the end of this part to add:—"A check weigher so removed shall not again be stationed at any mine belonging to the same owner. A check weigher shall not be an official of a trades union. The appointment of a check weigher is to be done in writing by the men employed in the mine who are desirous of making such appointment, and only those who sign such appointment are to have their output checked by the weigher and are to pay him for his services." In furtherance of this clause it will be necessary to repeal the short Act passed in last session of Parliament in regard to check weighers.

Clause 20.—**Every mine to which this Act applies shall be under the daily supervision of either the manager, or of some person holding a manager's certificate and nominated in writing by the manager to exercise the function of such daily supervision.**

But such nomination shall not in any wise impair alter or affect the personal responsibility of the manager under this Act.

The Committee consider that the last sentence of this clause, "But such nomination shall not in any wise impair alter or affect the personal responsibility of the manager under this Act," should be deleted. If a mine is under the daily supervision of a person holding a manager's certificate, that person should be responsible for his actions under the Act.

Clause 31.— . . . . . **The owner, agent, or manager of every mine shall also on or before the *first* day of *January* in every year, and at any other time when required by the Secretary of State, send to the inspector**

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of the district a return of facts relating to such mine in the form in schedule three of the Act, or in such other form as may be from time to time prescribed by a Secretary of State.

The Committee consider this should be altered to the fifteenth day of January, the same date as for the other return, and that the facts should be as they existed on the 31st day of December preceding.

Clause 34.—In any of the following cases, namely,

(i.) Where any working is commenced for the purpose of opening a new shaft or a seam for any mine to which this Act applies;

(ii). Where a shaft or seam of any mine to which this Act applies is abandoned or the working thereof discontinued;

(iii.) Where the working of a shaft or a seam of any mine to which this Act applies is recommenced after any abandonment or discontinuance for a period exceeding two months; or

(iv.) Where any change occurs in the name of, or in the name of the owner, agent, or manager of, any mine to which this Act applies, or in the principal officers of any incorporated company which is the owner of a mine to which this Act applies;

the owner agent or manager of such mine shall give notice thereof to the inspector of the district within two months after such commencement, abandonment, discontinuance recommencement or change, and if such notice is not given the owner agent or manager shall be guilty of an offence against this Act.

In many collieries some seams are only worked at certain times of the year, and the working of a seam may be discontinued temporarily from disputes with the workmen, want of sale for the coal, or other such causes. The Committee consider that such notices are unnecessary and vexatious, and that clause 34 should read as follows, viz.,

In any of the following cases, viz.,

(I.) "Where any working is commenced for the purpose of opening a new shaft for any mine to which this Act applies."

(II.) "Where a shaft of any mine to which this Act applies is abandoned, or the working thereof discontinued for six months."

(III.) "Where the working of a shaft of any mine to which this Act applies is recommenced after any abandonment or discontinuance for a period exceeding six months, &c., &c."

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Clause 37.— . . . . . Notice of the appointment of every such inspector shall be published in the London Gazette.

The Committee consider that, in addition to the above, the following should be inserted:—"Notice of the appointment of every such inspector shall be sent to each colliery in the district, to be posted up."

Clause 42.—A Secretary of State may at any time direct an inspector to make a special report with respect to any accident in a mine to which this Act applies, which accident has caused loss of life or personal injury to any person; and where it appears to the Secretary of State, either before or after such special report has been made, that a more formal investigation of the accident and of its causes and circumstances is expedient, the Secretary of State may direct such investigation to be held, and with respect to any such investigation the following provisions shall have effect:

(1.) The Secretary of State may appoint an inspector to hold such investigation, and may appoint any person or persons possessing legal or special knowledge to assist him in holding such investigation.

(2.) The inspector and any person or persons so appointed (herein-after called the court) shall (unless otherwise directed by the Secretary of State) hold the investigation in open court, in such manner and under such conditions as they may think most effectual for ascertaining the causes and circumstances of the accident, and enabling them to make the report in this section mentioned.

(3). The court shall have for the purpose of such investigation all the powers of a court of summary jurisdiction when acting as a court in hearing information for offences against this Act, and all the powers of an inspector under this Act, and in addition the following powers; namely, ...

The Committee consider that an inspector who has already reported is thus committed, and should not be appointed to hold the formal investigation, but that another inspector or other person should do so.

Clause 44.— . . . . .

(8). Any relative of any person whose death may have been caused by the accident with respect to which the inquest is being held, shall be at liberty to attend in person or by agent, and to examine any witness, subject nevertheless to the order of the coroner.

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The Committee consider that the following should be added—"And the owner, agent, or manager of the mine should have a like liberty."

Part II.—Rules.

Rule 2.—**Where a fire is used for ventilation, either the fire shall be fed with fresh air and have a dumb drift or airway through which the return air shall pass into the upcast shaft clear of the fire, or the air from the respective returns shall be mixed together at a proper distance before reaching the fire.**

As in some of the Scotch coal-fields fire-damp does not exist, the Committee think it a hardship, and will serve no good purpose to apply rules to them which are evidently intended for fiery mines. They, therefore, consider that this rule should read:—"Where a fire is used for ventilation in a fiery mine, either the fire shall be fed" &c., &c.

Rule 3.—**Where a mechanical contrivance for ventilation is employed, it shall be in such position and placed under such conditions as will tend to ensure its being uninjured by an explosion.**

This rule is exceedingly indefinite. Fans for ventilation are now placed in all positions, from close to the pit-mouth to many yards therefrom, and it remains to be proved whether the risk of their being injured by an explosion is lessened by distance from the shaft. Should the interpreter of this clause fix an arbitrary distance, many fans now efficiently doing their work might have to be removed at great inconvenience and expense. The Committee consider the clause should either be deleted, or read—"Where a mechanical contrivance for ventilation is employed, it shall not be immediately over the shaft." This will obviate what may be recognised as a position of danger.

Rule 4.—**A competent person or competent persons appointed in writing by the owner, agent, or manager for the purpose, shall immediately before the time for commencing work in each shift inspect with a locked safety-**

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lamp, every part of the mine in which work is to be commenced, and the roadways leading thereto; and shall make a true report in writing, in a book to be kept at the mine for that purpose and accessible to the workmen, of the condition thereof so far as ventilation and safety are concerned, and a workman shall not go to work in such part until the same and the roadways leading thereto have been so reported on. Every such report shall specially state where noxious gas, if any was found present, and shall be signed by the person who made the inspection.

It was considered that the appointments in writing of the competent persons referred to in this and following rules will be difficult to carry out in practice, as in the event of the illness of such persons or their absence from work, whether intentional or by accident, great inconvenience might ensue to the owner and the persons employed. The Committee consider that so long as a competent person does the inspection, his appointment in writing is unnecessary, and they do not know of any good reason for changing the existing practice in this respect.

The Committee also consider that it is unnecessary and inexpedient to inspect a mine in which fire-damp does not exist, with a locked safety-lamp, as this can be far more efficiently done with an open light. They also are of opinion that the word "immediately" is too indefinite, and might be interpreted in such a way as to be quite unworkable. The Committee consider that rule 4 should read as follows, viz.:—"A competent person or competent persons appointed by the owner, agent, or manager for the purpose shall before the time for commencing work in each shift inspect every part of the mine in which work is to be commenced, and the roadways leading thereto; and shall make a true report in writing in a book to be kept at the mine for that purpose, and accessible to the workmen, of the condition thereof, so far as ventilation and safety are concerned, and a workman shall not go to work in such part until the same and the roadways leading thereto have been reported to be safe. Every such report shall specially state where noxious gas, if any, was found present, and shall be signed by the person who made the inspection. In a mine in which inflammable gas has been found within the preceding twelve months, such inspection shall be made with a locked safety lamp." The Committee presume that this clause, as it stands,

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contemplates having the report books in the mine. They do not consider this a wise arrangement, as the books will then be less under the inspection of the superior officers of the mine, and may be destroyed in the event of an explosion or accident.

Rule 9.—**In any seam of a mine in which inflammable gas has been found within the preceding three months, no lamp or light other than a locked safety lamp shall be allowed or used ; nevertheless, exposed lights may be used at the bottom of the downcast shaft.**

This rule in its application to Scotland involves a revolution which is neither necessary nor expedient. Most of our Scotch coal and ironstone mines are, and have always been, safely worked with naked lights with great advantage in the matter of a good light for inspecting roof and sides and directing the miner at his work and for his safety. In such mines, gas may be occasionally found, perhaps at long intervals, in some fall from the roof or at a fault or trouble. To alter the lamp which has been used with safety in such mines for the best part of a century because a little gas is thus seen, is quite uncalled for, and contrary to the recommendation of the Royal Commission. The Committee consider that this should be a matter for arbitration, and that the first part of Rule 9 should read as follows, viz. :—"In any seam of a mine in which inflammable gas has been found to a dangerous extent within the preceding three months, it shall be in the power of the Secretary of State to require that no lamp or light other than a locked safety lamp," &c., &c.

Rule 12.—**Any explosive or inflammable substance shall only be used in the mine below ground as follows :—**

(*a*) **It shall not be stored in the mine :**

(*b*) **It shall not be taken into the mine except in cartridges in a secure case or canister containing not more than five pounds :**

Provided that on the application of the owner, agent, or manager of any ironstone mine in the lias formation, the Secretary of State may by order exempt such mine from so much of this rule as forbids taking an explosive or inflammable substance into the mine except in cartridges.

(*c*) **A workman shall not have in use at one time in any one place more than one of such cases or canisters ;**

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(*d*) In charging holes for blasting, an iron or steel tool shall not be used, and a person shall not have in his possession in the mine underground any iron or steel tool, and an iron or steel tamping rod or stemmer shall not be used for ramming either the wadding or the first part of the tamping or stemming on the powder, nor shall coal or coal dust be used for tamping:

(*e*) No explosive shall be rammed with violence or forcibly pressed into a hole; and a charge of explosive which has missed fire, or a hole charged with explosive, shall not be unrammed:

(*f*) In mines where inflammable gas has been found during the preceding three months—

(i.) Gunpowder or other similar explosives shall only be used when no person is in the seam of the mine or in any workings connected with the shaft on the same level, except those engaged in firing shots, or such other persons as are necessarily employed at ventilating furnaces or steam boilers, the total number not to exceed ten persons:

(ii.) A shot shall not be fired until the place of firing has been examined for gas by a competent person appointed by the owner, agent, or manager in writing for the purpose, and has been reported by such person to be safe for firing, and a shot shall not be fired except by or under the direction of a competent person appointed as aforesaid for the purpose.

In the first part of this rule, the term "inflammable substance" is used. This could be interpreted to include the oil or spirit in the lamps or flasks as well as explosives. The Committee consider this part should read as follows, viz.:—"Any explosive or substance used for blasting shall only be used," &c., &c.

(*d*) The word "tool" used in this part is too indefinite, as it might be interpreted that an iron hammer is not to be employed for tapping the stemmer. The Committee consider that the words "needle or picker" should be substituted for the word "tool," and they think this is what is contemplated.

(*f*) This part of this rule is one of the most serious proposals in the Act. The Committee fully discussed it, and were unanimously of opinion that it is quite unworkable in many circumstances that occur in mines. Some mines, especially ironstone ones, where blasting is continually and safely carried on, will require to be abandoned if the rule remains unaltered. In driving mines to cross faults and dykes, work is always carried on continuously,

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and blasting is constantly taking place. Such mines generally are non-gaseous, and are often at long distances from the shafts as well as the working places, so that to withdraw the men is not reasonably practicable. The Committee are of opinion that interference with blasting should be limited to extreme cases and to where it is employed for coal getting. They, therefore, consider that (*f*) should read as follows, viz. :—"In mines where inflammable gas has been found to a dangerous extent during the preceding three months, it shall be in the power of the Secretary of State to require that gunpowder or other similar explosive shall only be used for coal getting when no person is in the seam of the mine or in any workings connected with the shaft on the same level, except those engaged firing the shots, or such other persons as are necessarily employed at ventilating furnaces or at steam boilers, the total number not to exceed ten persons; but such explosives can be employed in stone mines or at other stone work, or for working ironstone all as next provided for."

Rule 23.—**Where the timbering of the working places is done by the workmen, suitable timber shall be provided at convenient places, and the distance between the timber or props when set, and sprags or holing props, shall not exceed six feet or such less distance as may be ordered by the owner, agent, or manager; and, in addition to the examination before the men commence work, each working place shall be examined by a competent person at least twice during each shift.**

While the Committee were unanimous that to have a rule fixing the distance between sprags or holing props will tend towards safety, they were of opinion that a similar rule, as regards props for the roof, is inexpedient. In many cases, the roof is so strong that props are not required, and, where props are required, it is far better that they be set where necessary to secure safety, than that a hard and fast distance between them should be fixed. The Committee consider that Rule 23 should read as follows, viz. :—"Where timbering of the working places is done by the workmen suitable timber shall be provided at convenient places and set where necessary to secure safety, and the distance between the sprags or holing props shall not exceed six feet," &c.

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The Committee are of opinion that, with these alterations so as to render it workable, the proposed measure with our present knowledge embraces all that legislation can do to ensure safety in our mines, and with these suggestions they leave the matter in the hands of members for further discussion.

On behalf of the Committee,

JAMES S. DIXON, *Convener.*

The PRESIDENT said the Committee had had five meetings, of about an hour and a half's duration each, and the Bill was gone over and carefully discussed in all its details. It would be well that members who wished to study the matter properly should have the Bill before them, and go over the Report clause by clause. If that were done by next meeting he had no doubt a good discussion would result.

The following discussions then took place:—

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DISCUSSION OF MR GILCHRIST'S AND MR GRANT'S "NOTES ON TRIALS WITH SETTLE'S GELATINE WATER CARTRIDGES."

MR J. H. RONALDSON communicated the following:—

Some time ago I took a note of the following explanation given about fumes from dynamite blasting, and give it for what it is worth:—"Dynamite develops nitrous fumes when it is exploded. The development of these fumes is due to the fact that during combustion the atoms of nitro-glycerine are converted into gas with such enormous rapidity that in their divided condition—*i.e.*, when mixed only with an inexplosive absorbent, such as kieselguhr—they have not the time to communicate explosion to each other throughout the whole mass of the charge, and a portion is consequently blown out of the bore-hole unconsumed. The energy developed by the explosion of the main bulk of the charge so acts upon the unconsumed portion of the nitro-glycerine as to convert it into vapour, which mixes with the atmosphere, and, along with the smoke of the fuse, hangs about the face of the work for a considerable time. This it is which causes the fumes which are detrimental to the health. The use of lithofracteur does not develop any fumes by its explosion if properly used, as shown by experience. The reason of this is that, while lithofracteur contains a smaller percentage of nitro-glycerine than dynamite, it also contains other ingredients which, while acting as perfect absorbents, assist also in the explosion, and enable every atom of the nitro-glycerine to be exploded in the bore-hole, thus preventing any portion being projected into the air in the form of poisonous gas, the result of imperfect combustion." These nitrous fumes—or peroxide of nitrogen, as I take them to be—have an extremely irritating action on the lungs whenever a small quantity of it mixed with much air is breathed; but peroxide of nitrogen in the presence of air is readily soluble in water. There is thus a possibility that the water in Settle's cartridge may absorb a part of these noxious fumes, and that in spite of the fact that Mr F. J. Rowan calls attention to—viz., that the water is

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formed into steam by the heat of the explosion—for, unless the atmosphere be extremely dry, the steam will be speedily condensed, and ought partially to wash the atmosphere.

Mr JAMES GILCHRIST said since last meeting they had had at Earnock further experiments with the water cartridge, but using a new explosive named gelignite. In communicating with Mr Taylor, consulting engineer for Nobel's Coy., he told him they had found this new explosive to work very well in the Wigan district, where gelatine dynamite had failed to bring down the coal. On Tuesday and that day they had trials, but, without going into details, he thought it was sufficient to say the gelignite was a failure. It was a little difficult to account for that, but Mr Bonser, who was present to give some explanations on behalf of Nobel's Coy., might be able to say something by way of explanation.

Mr BONSER said with regard to the gelignite it was quite true the results at Earnock Colliary were not such as would recommend it as a perfect substitute for gunpowder, but he thought it could scarcely be expected to be otherwise, from his not knowing the nature of the coal so well as he might after further experience. At Earnock, it was a very hard coal, and yet a soft coal, and they wished to see how gelignite would work, for after trying gelatine-dynamite in the Wigan district, they found gelignite to answer better there. It seemed in this case it did not. He could scarcely say why it was so, but in each case the shots blew out, and certainly the gas evolved by the discharge did not do its work. Probably it was liberated too rapidly. The coal, as he had said, was a hard-soft coal, requiring very much longer application of power to bring it down than this gelignite gave. The gelignite would be more likely to blow down the roof than the coal. The force was sufficient, but they had not yet found out the proper way of applying it. With a little experience of the coal they might be able to give better results than they did that day; at any rate, it seemed that gelatine dynamite blew that coal much better than the gelignite. Referring to the chemical action of the fumes, Mr Bonser read the following:—

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Extract from letter from Mr George M'Roberts, Chief Chemist of Nobel's Explosives Co. (Ltd.), dated from Ardeer, 18th December, 1886.

"The gelatine-dynamite and gelignite are made as nearly as possible in chemical equivalents, that is, there is as much oxygen present as will convert at the moment of explosion all the carbon and hydrogen into carbonic acid and water. When the explosion is perfect, therefore, the gases are—carbonic acid, CO_2 : water, H_2O. ; and nitrogen, N. These gases are comparatively harmless, as you know.

(Colonel Ford, in his recent report on the Crarae Quarry accident, is stated by the newspapers to say that carbonic acid is a poison ; but he is wrong. It is not a poison in the sense that arsenic, or prussic acid, is. It kills by taking the place of atmospheric air, so that a person who dies from it, dies solely from want of air, and not from any poisonous effect of the carbonic acid.)

When the explosion is imperfect, as is sometimes the case when bad detonators are used, the gases evolved are nitrous and hyponitric acids, water and carbonic oxide. The oxides of nitrogen and carbonic oxide are decidedly hurtful, and if a mixture of them in common air be inhaled, nausea and headache are produced ; and if the gases are very strong, syncope and death may result. You will see, therefore, that the gases to be feared are those only where the explosion is *imperfect*. Where the explosion is complete, the gases have *no hurtful effect*, because they speedily get taken away by the current of air in the workings, and when mixed with air they are not felt.

But as you will see from Colonel Ford's report, the gases from exploded gunpowder are very dangerous. In my opinion they are much more dangerous than those from any of our explosives. It is impossible to have an explosive that will not evolve those gases in greater or in smaller quantity. It is the very essence of an explosive to evolve gases at the moment of explosion ; and the gases evolved from gelatine compounds are probably less hurtful than those from other explosives. Gunpowder evolves in addition to the above, sulphurous acid, and sulphuretted hydrogen—the latter a decidedly poisonous gas."

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Speaking of the water cartridge, Mr Bonser said it seemed to be taking very well indeed. They sold it better where the use of gunpowder was prohibited, and in such cases they had very good results, and in one case he had before him the report of an actual saving of 15 per cent., while in a great many places where the cartridges were in use, the results were very much better. When a new thing was started, it required a little time before they learned to apply it in the best way. As to the system of firing, at first it was not perfected; but now the difficulty was overcome, and out of a continuous record of 5000 shots they had not had a single mis-fire. It was a great advantage to have the instrument entirely under control, as there was no hanging fire as in the case of a fuse.

Mr GILCHRIST said, in the experiments with the gelignite, the explosive was put nearly to the back end of the hole, there being only from one inch to two inches of water behind the cartridge, and it did not seem to have any bad effect at all. Where they got a chance of seeing the shot when it exploded, there was no flame, and the fumes were, if anything, less than from the gelatine dynamite. With regard to the battery firing the gas, some of the papers had taken the subject up and said a good deal more than they ought to have done. After seeing the correspondence, it occurred to him, from the small spark that caused the fire, that he had seen as large a spark with the electric signals underground. He had therefore got a battery erected, and managed to fire the gas with a seven-cell battery. He had been making inquiries, and found the electro-motive force of each cell was 1·1, so that he might say the seven cells were equal to 7·7 volts.

The SECRETARY said that with the trials of the gelignite, in all cases when coal was brought down, there was still as much of the hole left on as had been occupied by the cartridge. This pointed to some defect which deserved attention. In some cases, the coal was brought down in a shattered condition, showing that the force exerted at that point was too strong; yet, with all that, the part in which the cartridge rested remained.

The PRESIDENT suggested that the cartridge inside the casing

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should be removed further back. He agreed that the explosive was in its infancy, and he never saw a thing do yet without some trouble and trial. He recommended that the matter should be prosecuted until it was made successful. Apart from the blowing out of the holes and the failing to bring down the coals, the most material point was the shattering of the coal. In any trial he saw, the coal was shattered. Now, the demand was for round coal. It was not a smaller percentage of actual dross, but big lumps, and gunpowder did that to greater advantage than any other explosive. The President then went on to suggest that the cartridges might be reduced. Powder, he pointed out, only required an inch hole; with the water cartridges, it was 2¼ inches. Make the cartridges longer, he added, and less in diameter. Experiments, at least, should be made until they made it a success.

In reply to Mr HILL, the PRESIDENT said, as a rule, with gunpowder, the coal was broken down to the back of the hole.

Mr ROBERT M'LAREN said at Bog Colliery, in the Main coal, from one foot to three feet of coal was left on, but in the Splint, which was harder, they found a different result. He thought it went to show that gelatine had an advantage in the hard coal.

Mr ROBERT BEITH said his brother, in sinking a pit at Preston Grange, tried the water cartridges in hard rock, fakes and soft metals, always with the result that about a foot was left on.

Mr JOHN GRANT said he thought this would depend very much on the nature of the coal. At Bog, where there was so little of the hole left on, it was the Splint coal seam, in which the joints were numerous, which would facilitate that very much.

The PRESIDENT, referring to the expression in Bog table, "coal cleaned off by miners," asked if this coal was loosened so as to be easily brought down?

Mr GRANT replied in the affirmative.

Mr BEITH, referring to statement, p. 198, as to the advantage of the gelatine in shale workings, said in view of the defects in the coal he was of opinion it would be much worse in the shale, because unless the shale were brought down at once, it would not work very well.

Mr GRANT said that was why he would differ from Mr Beith.

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He thought it needed that. The coal was brought down too quickly, but in shale working the sudden concussion would be better. But it was not only that. As there was in shale workings a great amount of powder used, there would be less smoke if gelatine were used.

The PRESIDENT remarked that this was one of those cases where experiment would determine the best method.

Mr STEWART, as to the place occupied by the cartridge, said it did not matter how far it was put in or how near the end, if fairly executed, it would bring down the portion that gave the least resistance.

Mr BONSER said the position of the explosive in the case, so long as it was supported and they had a quantity of water surrounding it, was a matter of no great importance. He thought it was scarcely reducible in diameter. They could reduce the length, but the water had the effect in some soft seams of distributing the force of the explosion. Mr Gilchrist had alluded to the battery, when only a few inches of cable were attached to it, as having exploded ordinary lighting or household gas. Of course all those who had seen the experiments knew that the man did not turn the handle until he saw that all was right, and the explosion was generated inside the conductor, but even in that case the fuse was such that unless manipulated with the express object of finding a spark, they could not get one. In the manner described by Mr Gilchrist, there was no doubt it made a minute spark, but to obtain that they must manipulate in so short a length as would not occur in a pit. People, as those interested in other inventions knew, took a delight in finding the slightest flaw. Mr Gilchrist's discovery was magnified by others, and represented to be a source of danger, but there was no danger to be apprehended of the battery firing gas. The newspapers would also make out that the cartridges fired gunpowder. He had fired them in repeated trials, and they never fired the powder. The water was nearly as readily displaced as the powder itself, but if the water was held in its position, it thoroughly prevents the expansion of flame; but if they fired the cartridge free, the water being easily dissipated, and there being no superincumbent weight, the water might be

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liberated, and the flame pass to the powder. If, however, they added the necessary outside pressure, and kept the water there, in anything approaching the condition of things in the mine, they could not get any flame. He was willing to repeat his trials and he would guarantee that the gunpowder would not be fired under these conditions. As to the holes left on, he thought that was owing to the nature of the coal. In a harder and finer grained coal, they did not have that defect. In shales, no doubt about it, the explosion would be a good deal more effective than gunpowder, because generally with powder they had to break the shale up, so the shattering would be advantageous. As he had said, the shattering effect was reduced by the water, and in other places he could assure them they had not had such shattering effect, although in the experiments here it was so. They must have a certain quantity of water all round so that they could not readily lessen the size of the water cartridge. As to the electromotive force of the battery, he would leave that to the electricians. Batteries vary very much according to the different makers, but if they reduced their questions to writing, he would get the information first hand, so that they would not be misled in any way. In a fine grained or crystallised, very hard, sharp rock, he thought it was possible they might observe sparks, and he thought it right to mention that it would not be from the cartridge but from the friction of splinters of rock upon the rock itself. That, however, was not usually met with in coal mines.

Mr GILCHRIST said he thought they had overlooked one fact as to not blowing over the end of the hole. In the case mentioned at p 174, there were 7 oz. of gelatine used, and the shot blew 15 inches over the hole but did not bring down the sides well. But possibly it was overcharged. Indeed, he was strongly of that opinion, and if experiments were made in the rock they might learn something. Mr Bonser said it was considered impossible to do away with the water round about the cartridge. He thought Commissioners who were appointed in Germany to inquire into explosions, reported that some of the higher explosives could be used without any danger of igniting gas. He did not remember the names of the different explosives, but

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he took it gelatine dynamite was one of them. Had Mr Bonser ever seen any shots fired without the water?

Mr BONSER said he might say he had fired the explosive for experimental purposes in dust. Of course gases in the coal pit were easily dealt with. They knew where they were and could remove them at will, but dust could not be disposed of in the same way. He had fired the cartridges in the most inflammable dust suspended in the atmosphere, but in no single case had the explosive fired the dust. The explosive was so sound in itself, the combustion was so perfect, that it did not require any assistance from the atmosphere, and when he fired it in the dust he had not found it to ignite the dust. He thought they had not made it a success in this case, because they had not the best explosive for the special coal at Earnock Colliery.

Mr GILCHRIST said he thought it only fair that he should corroborate what Mr Bonser had said. At Earnock there was a shot fired in the coal dust without the water cartridge and it did not explode the dust while the powder did.

Mr WM. DUFF asked if Mr Bonser meant that the water round the cartridge had not more effect than the explosive itself. Water being incompressible, it appeared to him to work somewhat like hydraulic power. The explosive being cushioned by the water, it was the water working more than the explosive.

Mr BONSER said he should not like to say that the water had no effect. The effect was this: the force was distributed. Whether it was the pressure of the water or the gas evolved by the explosion, which he thought was the more probable cause, at any rate the water took away from the explosive the shattering effect it always had hitherto. They never could make it commercially a success on account of the shattering nature of the explosive, and the water certainly had taken away to a great extent that shattering effect and distributed the force and made it more commercially valuable than before.

Mr ROBERT M'LAREN said this brought a very important point before them. Nobel claimed for the gelatine that the action was not so sudden as the dynamite. At last meeting Mr Rowan told them—and he thought he was right—that the water at the end of the cartridge was meant to reduce the shattering

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power and also the explosive power of the gelatine. Would it not be a good thing to have more water at the end of the hole. In that way, it might reduce the very sudden explosive force. The experiments at Bog Colliery would have been more successful had the explosive force been less sudden. If there was something of that kind it might be a success. Gunpowder did the work much better, being much slower in its action. He thought Mr Grant, in his notes, had omitted some little things. He thought he should have done what Mr Gilchrist had done, viz., stated how much of the holing was left on and how much coal was liberated. He thought he might arrange to have that information for next meeting.

Mr Wm. Duff said what he meant to bring out was if the water had an effect a great deal would depend both on the stemming and the surroundings. It should do a great deal better if, when put in, no corners were left, but it be properly fitted in every way.

Mr F. J. Rowan said he would like to ask if there were any special reasons for the diameter of casing that had been chosen and the leaving of only a small quantity of water round the cartridge. Had the cartridge been tried with a larger diameter of casing giving a greater thickness of water? It seemed to him that it was probable a better result might be got if the casing were made shorter, so that there was less water at the ends and more surrounding the cartridge. The reason for that idea was that, as had been remarked, water was practically incompressible, so that the quantity which was behind the cartridge simply prevented the effect of the shot reaching to the end of the bore-hole, while the quantity in front was likely to be forced forward like a solid bolt thus carrying the force of the explosion in a direction in which it would not do the greatest work. With reference to the remarks about sparking, he had noticed in a recent volume of the journal of the Iron and Steel Institute (vol. i., 1886, page 281—from Glückauf, 1885, No. 90), the following notes of trials made in Germany with dynamite cartridges surrounded with water:—"In some experiments made at the collieries of the Bonifacius and Zolloerein Associations, in the case of eight shots in which the dynamite was surrounded by water, part of the

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bore-holes being in rock and the remainder in coal, fire was observed on each occasion, this being sometimes accompanied by showers of sparks, thus proving that the use of water is not a sovereign specific under all circumstances for the prevention of explosions due to shot-firing." Mr W. Galloway also, in discussing some experiments with coal dust (in Trans. N. of England Inst. of M.E., vol. 34, p. 303), said that he had made a large number of experiments with the dynamite water cartridges invented by Sir Frederick Abel, which were fired by electricity, with the result that a few sparks were seen to issue from the bore-hole, even through four feet of water. He expressed a decided opinion, however, that shots of that kind fired in a mine where coal dust was present would not produce an explosion from the ignition of the coal dust. He did not mention the probable effect if gas were present. Referring to the question of fumes from explosions, he (Mr Rowan) had been since last meeting looking up various authorities to see if he could get any reliable analyses of fumes from the explosion of dynamite and nitro-gelatine, but without success. He could not find any in Sir F. Abel's numerous papers on explosives; and in Mr M'Roberts' paper (in Proc. Phil. Soc. Glasgow, 1882-83, vol. xiv., pp. 273-287), all he could find was the following equation, showing the chemical reaction of the complete combustion of nitro-glycerine, viz. :—

$$2\,(C_3\,H_5\,O_3) = 6\,CO_2 + 5\,H_2\,O + 6\,N + O.$$

$$\underset{\text{(Nitro-glycerine)}}{3\,(N\,O_3)} = \text{(carbonic acid)} + \text{(water)} + \text{(nitrogen + (oxygen).}$$

These, however, were the products only from a theoretical point of view. Mr Ronaldson in his remarks which had been read by the Secretary, had pointed out one cause which prevented a theoretical result being reached, viz., incomplete or imperfect combustion, and to that the speaker would add another cause, viz., dissociation. At the high temperature of explosion, some of the carbonic acid and water must be dissociated, and it was highly probable that from both causes nitrous compounds would he found in the resulting gases instead of mere nitrogen which is not injurious. He thought they still wanted some analyses of

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the gases actually produced by the explosion of these explosives, not mere chemical equations expressing the chemical changes which ought to take place under theoretical conditions, but analyses of what was found present in practice. In a lecture given by Captain Noble, C.B., F.R.S., at the Institution of Civil Engineers, in 1884, on the "Heat-action of explosives," there were some analyses shewing the composition and products of explosion of gun-cotton and of several kinds of gunpowder. Something similar was wanted for dynamite and nitro-glycerine.

Mr BONSER said it would not be economical to make the bore any larger. It would be an objection on the part of the men to bore a large hole. As regarded the analysis of the fumes, he would lay this matter before a competent authority, and get, if possible, some information upon it.

The PRESIDENT, in adjourning the discussion, said they were at one in the matter of safety, but the weak points were, it did not bring down the coal so completely and in such good condition as powder. He strongly urged the proprietors to seek to remedy these defects.

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DISCUSSION OF A DESCRIPTION OF "A SELF-ACTING BRAKE FOR PREVENTING OVER-WINDING."

Mr J. H. RONALDSON communicated the following:—The ingenious and simple apparatus of Mr Gilbert M'Pherson for preventing over-winding is, I think, a step in the right direction, although in some quarters any device of a like nature gets the cold shoulder. It is interesting to note that a similar idea has been proposed among the Belgians, coupled with Mr Robert Beith's suggestion that the steam should be cut off at the same time. In Westphalia it is universal to have steam brakes on the winding engines, and in many cases there is in connection with the steam brakes a small piece of mechanism worked off the crank which automatically brings the steam brake into play in the event of the engine going too far. It was noticeable, also, that these contrivances were used not instead of detaching hooks but along with them.

Mr LAURENCE HILL said the principle was not new, as he saw it thirty years ago.

Mr A. M. GRANT quite agreed that the apparatus, in the event of the engine being started the wrong way, would act immediately, but would it work effectually in a case of over-winding or a valve going wrong? Would that brake stop the cage from going to the pulleys? He thought it would not. In regard to what the Secretary had read, there were many cases in this country of similar appliances, not only for putting on the brake but for reversing the engine also, and even for shutting off the valve, and these applied gradually; but in no instance had any of them been a very great success. In many cases the wear and tear of the working parts had caused them not to act effectually when required. He thought that the principal objection to this arrangement in regard to over-winding was, if it took place at the full speed of the engine it would not work.

Mr ROWAN said he noticed in a volume of the "Proceedings of the Institution of Civil Engineers" a description of apparatus to prevent overwinding in constant use on the Continent, principally in Belgium and France, and it might be useful to the members of the Mining Institute to give them the reference—

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83rd volume of the "Proceedings of the Institution of Civil Engineers." p. 519. A common arrangement, and one which is very satisfactory when the upper part of the head-gear is sufficiently strongly framed, is said to consist in bringing the guide rods gradually nearer together at the top, so that the cage wedges itself, is brought to rest without shock, and remains suspended even if the rope breaks. Safety pawls are mentioned as an extra precaution, but are not necessary, as the cage cannot fall until the guides are slacked back. Other methods are mentioned, one of them being an arrangement of levers lifted by the cages, if raised too high, and connected by rods to levers in the engine-house, which close the throttle valve and brake the engine. The paper from which these abstracts are taken is by Baure, in Bulletin de la Société de l'Industrie Minérale, vol. xiv. (1885), p. 77, which contains illustrations of the various plans, and an account of the successful application of several of them.

Mr GILCHRIST said to give this self-acting brake a chance, he thought they would have to erect their pit frames a great deal higher than was generally the practice at present. In this district one-third of a stroke would take a good many of the cages to the pulley-wheels, so the weight would have to be something enormous to prevent overwinding. It might be applicable to slow engines, but not to the high speed engines they were accustomed to now.

The PRESIDENT said, while he did not want to throw cold water on anybody's inventive genius, he must say this was a matter that universal practice had relegated to a good engine and good engineman. Over-winding accidents were not of such frequent occurrence, and to obviate these the detaching hook had been introduced and been somewhat successful. He quite agreed with Mr Gilchrist that at the rate with which winding was done now-a-days, to put on a brake as proposed was of no great use. It might do with an old-fashioned system of winding at a slow rate with geared engines.

A vote of thanks was given to Mr M'Pherson and Mr Galloway.

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DISCUSSION OF MR PITKIN'S PAPER ON "A MINER'S ELECTRIC SAFETY LAMP."

Mr DAVID REID said—In reply to the President's remarks, I would suggest that, seeing Mr Pitkin has brought forward his miner's lamp, which is apparently suitable as to its light-giving qualities and also its safety, it only remains for the gentlemen present to give it a fair trial and prove its worth. I fancy I hear a great majority of the mine-owners say the cost is enormous, and they will not experiment with such an expensive lamp. Is there not, Mr President, in connection with the Masters' Association, a fund (as I know there is belonging to some associations in this country) from which grants are made in order that inventions may be practically tested? It would be sufficient if a sum of money were granted and the lamps arranged to be tried at any pit, where the necessary engine, dynamo and fittings for 100, 200, or 300 lamps could be placed, and a fair trial made of the system. In reference to other inquiries, I may say that the price of the lamp has already been much reduced, and I have no doubt that, if there was a good demand for them, the inventor would soon be able to still further reduce the price. Replying to questions, Mr Reid said he had learned from Mr Pitkin that the cost of 100 lamps, with dynamo and fittings for charging them, would be about £260, while 300 could be supplied and fitted rather more economically, as (although the dynamo would have a larger current) it would not cost a correspondingly greater sum. The price of the three lamps before them, which were serviceable articles, would be 40/. They burned for ten hours. The dynamo at Earnock could be used for charging the lamps, although a much simpler arrangement could be made if a dynamo were specially made for the purpose. The weight of the lamp was 6½lbs.

Mr STEWART—If overcharged, would the lamps go out?

Mr REID—No.

The PRESIDENT—What is the expense of keeping these in light 10 hours, in contrast to a lamp, which costs ½d to 1d.

Mr REID—I can scarcely go into that; neither could the in-

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ventor. The average life of the lamp is 800 hours. Mr Pitkin had no experience of the battery giving way. To replace a lamp would cost 5s.

Mr GILCHRIST said the lamp he had illuminated the face much better than any two safety lamps. At a distance of 8 or 9 feet back—being in the centre on a tree—it illuminated the whole working face very well indeed. He was quite surprised to see it.

Mr REID having arranged to forward six lamps for trial at Earnock for the purpose of being reported on, the discussion was adjourned.

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NOTES ON SINKING OF SHAFTS, AND ON THE WAY THEY ARE FITTED UP FOR PUMPING AND WINDING.

By Robert Beith.

SINKING, TIMBERING, WALLING, AND TUBBING.

Shafts are made for various purposes, as for travelling, winding, pumping, ventilating, or for exploring a district. Then there are staples, winzes, or small pits—termed by the Scotch miner, blind pits—which are made to connect one level of a mine with another. In most cases, shafts at collieries are sunk perpendicularly, though in others they are sunk diagonally, according to the "lie" of the mineral to be wrought, but the latter system is chiefly resorted to in metalliferous mining.

If the shaft is intended for working coal, the situation should, if possible, be in the centre of the coalfield and in the neighbourhood of a railway, so that every facility may be had for reaching the market. If possible, it is well to avoid sinking through bad ground, such as running sand or old workings, not only for the cheapness of sinking but for the greater permanency of the shaft. Advantage should also be taken of the declivity of a hill, the engine house being fixed on the upper side, as sometimes circumstances of this kind save expense in erections, and make it more convenient for the pithead, and tipping of material, and allow any water pumped out of the mine to run freely away. When shafts are situated near tidal rivers, or on the banks of rivers liable to fresh-water floods, or on exposed banks along the sea shore, care should be taken to have the pithead high enough to be out of reach of the destructive influence of the water. In some cases an adit level may be driven in from some low point on the estate towards the main shaft, which will serve not only to reduce the height the water has to be lifted from the mine, but may carry off a good deal of the surface water, which often forms a large portion of that which has to be drained.

It is very important to consider the circumstances of the deposit of the mineral to be wrought, and it will add much to the future of the mine if the position be well chosen. So far as this is concerned, the shaft should go down in the lowest part of the deposit, so that the mineral to be wrought, in being carried from the

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workings in the mine to the bottom of the shaft, will have the benefit due to gravitation. This remark is particularly applicable to steep lying seams, or those lying in basin form, or those which are disturbed by faults. It is, therefore, a decided advantage to have a knowledge of the way in which the strata are lying before sinking is commenced, so that the mode of procedure may be planned and designed beforehand.

It is necessary to consider beforehand, likewise, the probable depth to be sunk to, and arrange the kind of engines and machinery which are to be permanently used for winding from this depth. Before commencing sinking operations, the manager should provide a proper quantity of tools—such as picks, drills, hammers, wedges, shovels, kettles, barrels, &c.—and to anticipate the material that will be required in the prosecution of the work, and such work should be let to a set of men who have been accustomed to sinking.

There are various forms in which shafts are sunk—round, square, oblong, elliptical, and polygonal. In the North of England and South Wales, round shafts have the preference, and the size varies from six to twenty-one feet diameter, according to circumstances. When pits are subjected to side pressure, and have to be walled or tubbed, the round shape is the best and strongest; it is likewise cheaper to sink, as cutting out the corners of a square or oblong shaft gives more work. Whilst in England, Belgium, and France round shafts mostly prevail, in Germany the oblong is considered the most convenient, and the shafts for the most part are sunk in that form. In Belgium and France the shafts are sometimes sunk polygonal, that is having six, eight, or ten sides.

The specifications for sinking pits are so well known that it would be quite superfluous for details on this subject to be entered on here. When the sinking is in progress, a proper account should be kept of the strata sunk through, and the thickness of each bed carefully measured and noted.

If the permanent engine is not ready for work, sinking may be commenced without it, and the material may be hauled out of the shaft by a portable engine, having a winding drum attached to it for that purpose; or the pit may be sunk eight or ten fathoms by

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a common windlass. The pit should be sunk perfectly plumb, and for this purpose a centre line is kept wound on a hand drum, or reel, and a heavy "bob" is kept lying in the pit bottom which is attached to the line when it is run down, for taking the centre. A piece of timber is fixed across the mouth of the shaft with a wheel fixed on it, the groove of which corresponds with the centre of the shaft; by this means the pit may be plumbed at any time, and when the line is hanging in the shaft an iron rod just the length of the radius of the shaft is tried on all round from the line to the sides of the shaft, and any irregularities are notified and made right.

It generally happens that the strata next to the surface are composed of material of less solid character than that below, such as coarse gravel, clay, sand, or a mixture of these materials. In sinking through these it is necessary to put in timber to keep the sides of the pit from falling in. The strength of the timber should vary according to the size of the shaft, and may consist of pitch pine made into frames large enough for the shaft, each frame being formed of four pieces mortised together. These frames may be placed three or four feet apart, below each other, according to the nature of the ground being sunk through. Behind these frames backing deals, consisting of common fir 1½in. thick, should be placed, to keep anything from running into the shaft from the sides. The timbering should be carried down this way till a stone sufficiently strong is reached for putting down a walling crib, which forms a foundation for walling from. About ten fathoms will be found a convenient distance to go—provided a foundation can be got then—before the walling is commenced. If the square timber should not be sufficiently strong to resist the pressure of the shaft sides, circular frames should be used, made in segments to the sweep of the pit, and about 6in. square. If the pit is to be 11ft. diameter when the walling is put in, the diameter of the crib should be larger in proportion to the thickness of the walling; timber to be taken out as the walling is put in. The walling crib, if of iron, should be 12in. broad, and 1⅛in. thick, and cast in segments to suit the sweep of the pit, laid perfectly level, and filled in or wedged behind with fir wood endwise.

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The ordinary method of dealing with quicksands, &c., is to set off the pit very large, and drive down wooden piles, inside of which wooden cribs are laid. The piles are driven as close as possible, and the earth and sand dug out between them; then a ring crib is laid at the bottom and fresh piles driven down, and so on until the stone-head is reached. After this distance is reached the diameter of the shaft is reduced to its normal size, viz., 12ft., so as to give 11ft. clear of the walling: the sinking being still prosecuted with all speed, until a stone sufficiently strong is reached to form a foundation for walling. This is done somewhat after the manner shown on Plate XIX. The walling consists of bricks which should be of a special make to suit the circle of the shaft; the mortar should also be of the best quality, and care must be taken to insure good workmanship. After the walling is completed—which is performed from a circular scaffold 4in. less than the diameter of the shaft—the sinking is resumed below the foundation, and carried down plumb below the walling for three feet, after which it again widens out to its full size, 12ft., see Plate XIX., where it will be observed a bracket of rock or stone is left to support the walling. Below this bracket the sinking is continued the full size until a depth is reached at which walling again becomes necessary. A foundation is laid off in the same manner, and the walling carried up until the bottom of the stone bracket is reached. This bracket of stone is then cut away in small parts at a time, and the walling carried up to the bottom of the previous brickwork, and joined well together, and so on as long as good foundations are met for walling from. But as the sinking progresses further down, and the ground sunk through found not sufficiently strong for a foundation for the brickwork, it is then absolutely necessary to fix a walling curb for a foundation. The curbs can be made either of wood (oak or pitch pine) or cast iron, and made in segments to suit the circle of the pit. Holes 3in. dia. are bored 3ft. into the sides of the shaft and malleable iron plugs are fixed into the holes, to set the curb on. This is done somewhat after the style shewn in Plate XX., in which it will be seen made of cast iron in segments, bolted together. The plugs are 4ft. long, 3 feet of them being made to suit the diameter of the holes, the

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other foot being flattened for laying the curb upon. In boring the holes and fixing the plugs, care must be taken that in setting the curb to the plumb, it also is level for the walling to start from.

Many pits, especially in Staffordshire, are walled with dry brick work, the bricks being put longways, so that the walling is only 4½in. thick; this is very weak and unable to resist any pressure, and especially after being in for some time, has a very unworkmanlike appearance. The better way is to have wedge-shaped bricks made to suit the shaft, and these put in properly—endways, with mortar, so that the walling is at least 9in. thick, though the pit should be sunk to admit of 12in. work, the extra 3 inches being filled up with ashes or pieces of brick, stone, or mortar.

When there is much water to contend with, and tubbing has to be put in to keep it back, it is absolutely necessary to have the wedging crib or cast iron curb, which acts as a foundation for the tubbing, placed on a bed of rock which will hold water. When a bed of this sort cannot be found it is useless to put in tubbing, because after it is put in the water will find its way up through the bottom of the shaft when sinking is resumed. The wedging crib should be laid on a level bed prepared for it, and the space behind, between the crib and the pit side, should be tightly wedged with wood and iron wedges till no more can be driven in. The tubbing is cast in segments, a certain number to make up exactly the circle of the pit, the segments being usually about 2ft. high. After the crib has been laid, a pitch pine deal from ⅜in. to ½in. thick is laid upon it to form a joint, and a course of tubbing set up all round the shaft; there is likewise a thin deal inserted between the vertical joints. In each ring of tubbing the joints are crossed. Care must be taken to have each segment put in true and level at the horizontal joints.

The use of tubbing originated at the collieries in the North of England, and was first introduced into Germany at the Hibernia Colliery, Westphalia, in 1856, since which time it has been extensively used in that country. The following is a formula for finding the required thickness of cast iron tubbing according to the size of shaft and pressure of water :—

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Let P = Pressure or vertical depth in feet.
,, D = the diameter of the pit also in feet.
,, X = the required thickness in inches.
Then $X = \cdot 34 + \frac{P \times D}{3800}$

Thirty years ago the science that was displayed in mining operations in this country was very limited, and in many districts the principal seams of coal and ironstone which were then being wrought were near the surface, consequently no great engineering skill was required; and owing to the shallowness of these seams a number of pits of small area was the rule of the day; and as these workings advanced it was considered cheaper to increase the number of shafts than continue to extend the underground workings. These pits were rectangular in form, and were sunk in the rudest and most primitive manner. They were also divided into compartments for pumping, winding, and ventilation. This arrangement was, however, a very dangerous one, because if an accident occurred in the shaft all means of escape was cut off, as in the case of the accident which happened on 10th January, 1862, at Hartley Colliery, in the Newcastle coalfield, when the beam of the pumping engine broke and fell down the shaft. After this accident, whereby a number of lives were lost, the obligation of providing two different outlets was enforced by Government.

The passing of the various Acts of Parliament for the regulation of coal mines has given a great stimulus to the study of those scientific rules which have brought about these safe principles, which are acted on in the deep shafts of to-day, and which have made the life of the miner compare favourably with that of workmen in other employments.

During recent years, science has made rapid strides in mining operations, and all this has been brought about by our shafts getting deeper as the workings extended towards the bottom of the basin of minerals which are being wrought, and which called for the best methods of drawing our material from this increased depth.

The deep shafts of this district are those sunk into the bottom of what is called the Hamilton and Bothwell coal basin, and which has now become the centre of the mining industry in Scotland.

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The shafts will average about 280 yards in depth to the Splint coal seam. Spittalhill Colliery, in the Blantyre district, is 440 yards deep to the same seam of coal, and is at the present time the deepest working colliery in Scotland. The shafts, of which there are two, a downcast and an upcast, the dimensions of them being 24ft. × 7ft. inside of the wood, were superintended by the writer while being sunk to that depth.

Reference will now be made to some improved appliances for surface arrangements used in shaft sinking, and which have of late been introduced into these deep shafts. The first of these appliances is what is called the trolley, or bogie principle. In sinking a shaft two of these are used—one to land the bowks or kettles, from which the contents are tipped into the waggon; the other for landing the water barrels and discharging the water: see plate XXI. In the working of this system, two men are required on the pithead to work the bogie and change the hook to the empty kettle, run the bogie forward with the load, tip its contents and return to pithead with empty kettle, and so on. With the exception of the old style of striking the kettle on the pithead the writer believes that in England, Wales, and Scotland, this system mostly prevails; but as the sinking of the shafts got deeper, the time occupied changing the kettles at the top was not sufficiently rapid to give the clearance required in sinking through soft strata. It was therefore decided in the sinking of a colliery in the Hamilton district a few years ago to abandon this system and introduce another which is called the "Strike Tree." The strike tree is made of pitch pine, is 20ft. long and 12in. square, and is fixed on the top of the pithead frame with glands to the head gear and projects out 12ft. from the centre of the shaft: see plate XXII. From the end of it is suspended a chain of sufficient length and strength to carry the kettle of rubbish out from the shaft the required distance, for safety to the sinkers, before it is emptied. To facilitate the tipping of the kettle by this system, it is suspended by a bow of iron, which turns on two pins which are fixed a little below the centre of gravity on the outside: see plate XXII., and on one side of the kettle is a small catch, which by being secured to the bow prevents the kettle from capsizing in the shaft. By tipping the kettle in the way described, the

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rubbish runs down a shoot into a waggon, and no shovelling is required, so that a great saving of time is effected as well as greater safety to the sinkers. In connection with this arrangement there is an appliance worthy of notice called the "Sinkers' Grip": see plate XXII. It is fixed to the chain above the kettle and affords sufficient room for eight men to hold by when going down or coming up the shaft. It is much safer and better for the men than clinging to the chain as they used to do in the old way.

APPLIANCES FOR RESINKING SHAFTS MORE ESPECIALLY THOSE WHICH ARE RECTANGULAR IN SHAPE.

The first appliance is the "Kettle Rider," which consists of a frame-work of pitch pine, made to suit the gauge of the guides. On each side of the frame-work, are fitted malleable iron plates, bolted together so as to keep the rider stiff and true to the gauge, and allow it to run up and down the shaft with the kettle, which can be done at a much higher velocity in winding from the bottom of these deep sinking shafts, than could otherwise have been done: see Plate XXIII. The winding rope passes through a hole in the centre of the frame-work, and is kept in its place by a small piece being cut out the centre and hinged, to make it movable, and fixed by a pin. When the kettle arrives at the pitbank, the rider must first of all be secured, which is done by putting a bolt in a hole which is bored through the guides to carry it. The pin is then taken out to allow the rope to come out from the centre of the shaft, so as to strike the kettle on the pithead: the kettle is again pulled in to the shaft, the rope goes into its place, the movable part is then fixed, after which the rider is adjusted and then descends the shaft. As the kettle descends, the rider is supported by a round malleable iron ring, which is welded on to the capping or hose of the winding rope. At the bottom of the guides are fixed two buntons, one along each guide, with a sufficient grip to make them safe to carry the rider. The rider descends with the kettle until these buntons are reached, where it rests, and as the kettle continues its descent the rope passes freely through the hole in the frame-work until it reaches the bottom of the shaft.

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The "Swing Tree" is the next appliance, which has been in use for a few years past in deepening shafts from one seam of coal to another. It is made of malleable iron, and can easily be fitted up in any pit bottom where re-sinking is required: see Plate XXIV. By using this appliance to re-sink at night, it does not interfere with the winding of coal during the day. It must be fitted up in a position to sink the shaft, and at the same time to to keep the way clear for drawing the coals during the day. Neither of the cages requires to be taken off. It is arranged as follows:— Have a piece of chain or wire rope of sufficient length for the distance the shaft has to be sunk; fix it on the bottom of one of the cages, hoist it up the shaft, put on the kettle, and begin sinking. Ten minutes will put off or on the chain or rope.

The steel wire ropes for sinking shafts are also much improved during the past few years. Messrs R. S. Newall & Co.'s (of Gateshead-on-Tyne and Glasgow) patent make of ropes of right and left strands to prevent spinning in shafts have been found to be a great improvement on the usual form of rope as it almost entirely counteracts the tendency to untwist.

The colliery manager or sinking contractor who means to excel in the important work of shaft sinking, must be one who has had considerable experience with all the different strata which are to be sunk through. Each series of strata has its advantages and disadvantages; and the most successful sinker is the one who knows how best to use not only the various kinds of material and explosives, but also the various kinds of men. He must also have a good system of working. The marked improvement in steam engines, winding appliances, and modes of working coal, compared to what they were a few years ago, has led also to improved methods of sinking shafts. Power drills actuated by compressed air are now being used for this purpose. It may be stated that one of the writer's brothers in 1881 patented an apparatus for pit and shaft sinking, to facilitate the use of the power drills while at work. It consists of a ring frame of iron of the same shape as the shaft, and of somewhat smaller size. Upon the frame are mounted saddles which can be clamped to it in any desired position. To these saddles power drills are pivotted so that holes can be bored at different angles. Some of

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the power drills may be carried on the outside of the ring frame and some on the inside. The frame is suspended in the shaft by ropes or chains, and held in place for work by jacking screws. It is claimed for the apparatus that all the holes necessary for one depth of work may be bored with one setting of the frame, and that the middle of the shaft is always free, so that winding operations may be carried on while the holes are being drilled. The apparatus is described in detail in the specification, No. 674. A form of report of work done while sinking is appended: see p. 249.

The following are the particulars of the sinking of two shafts, named the Lady Windsor Pits, belonging to Messrs Davies, Scott, & Co., at Blackrock, near Pontypridd, South Wales. The downcast shaft is 19 feet in diameter clear of walling:—Sinking was commenced with a semi-portable engine, two 14 inch cylinders and 2 feet stroke, drum 6 feet diameter for round ropes, geared 2 to 1. The kettles used were capable of lifting 25 cwts. of material; the head gear or frame was erected on pillars of masonry with long beams of pitch pine to form the pit top, &c. This was erected before the cutting of the first sod, which took place on 16th June, 1884, at 2 P.M., by Morgan Joseph, Esq., manager and partner of the company, and after which the sinking was carried on continuously with three shifts of men,—eight hours each,—commencing at 1 o'clock on Monday morning until 7.30 on Saturday evening of each week.

Eighteen yards were sunk before the solid rock was struck, the ground sunk through being mostly gravel and running sand. The diameter of the pit to this depth was 22 feet 6 inches, it being necessary to have this diameter for timbering to secure the sides until the solid rock was reached, to admit the brick-work or walling without removing or interfering with the timber in bad ground. The timbering consisted of eleven curbs in segments 6 ft. 5⅛ in. long, and 9 in. by 4 in., and lagged behind with 2 in. and 1½ in. deals. From the depth of 18 yards to 94 yards, the strata passed through was 95 per cent. of Welsh pennant rock. At this depth the No. 2 Rhondda vein was struck, and at 190 yards the No. 3 Rhondda vein was struck. A lodge-room was made here to collect all the water above this

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point. When a depth of 200 yards was reached, larger engines were erected, viz., a pair of direct-acting coupled engines with 26 in. cylinders, 4 ft. stroke, with a 10 ft. diameter parallel drum for round ropes. The first steam coal vein, the Aberdare 4 ft. seam, was reached at the depth of 548 yards. The sinking was completed on 14th November, 1885,—total depth being 616 yards 8½ in.

A walling stage or scaffold 4 in. less than the diameter of the pit was used. It was made in two halves, with three chains or bridles to each half, welded into one large ring to lift them For this scaffold there were two crabs with steel wire ropes, one attached to each half of the stage; there were also six large iron bolts 2½ in. square, to rest on the walling to take the weight, &c. There was also a chain with hook attached for tipping the bricks on the stage for the bricklayers; the mortar was sent down in one of the bowks or kettles, and kept standing on the stage, with men to attend to the bricklayers and put the mortar on the wall when required. The first eighteen yards of walling was 18 in. and 2 ft. in thickness. In strong ground, the walling was only 9 in. in thickness, except where the curbs were fixed; 14 in. and 18 in. work on the curbs. This was done so that each length of walling could carry its own weight, as by cutting the ground out wider to suit the 14 and 18 in. work, and walling it all solid for 3 yards with good mortar, it was not possible it could move. From the depth of 500 yards the walling was increased to 18 in. and 2 ft. in thickness throughout to the bottom as circumstances required for the permanency of the shaft.

The surface arrangements at the pit were wrought with two trollies or bogies—one to land the bowks or kettles, from which the contents were tipped into waggons; the other for landing the water barrels and discharging the water. There were seven barrels of water per hour, each containing 250 gallons. This quantity of water had to be drawn until the sinking was completed. This growth of water caused a great delay, because, after walling, a period of twelve hours was generally lost in barrelling the water to get the bottom of the pit cleared.

The total time occupied in sinking and walling this pit, not

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including delays, erecting engines, and other contingencies, was 16 calendar months or, in other words, at the rate of 9·6 yards per week.

The total number of holes bored, ...	20,471.
The total number of holes blasted, ...	20,471.
Lbs. of dynamite used, ...	13,055.
Coils of fuse used, ...	2,512.
Number of detonators used, ...	20,500.

The upcast shaft was started on 13th October, 1884, at two p.m., and completed on 23rd January, 1886—this time including all delays, &c., in connection with the pit. Power drills were used in sinking through the pennant conglomerate and cock-shot rock—the hardest rocks met with in the Welsh coal field. This pit is 17 feet in diameter clear of the walling. It is walled throughout; and in connection with this pit it is but fair to state that there are also two brick arches in each of the three steam coal seams, all included in the time occupied in sinking.

The engines erected for sinking were 26 inch diameter cylinders, 4 feet 6 inch stroke, with a 12 feet drum for round steel ropes.

It may be mentioned that in the sinking of the new shaft at Niddrie Colliery, near Portobello, good success was achieved in regard to time. The sinking was commenced on Monday, 18th May, 1885, and completed on 2nd December of the same year. This pit is 17 feet in diameter, clear of the walling, and is walled throughout. The total depth sunk was 250 yards 6 inches.

No difficulty was encountered with loose gravel or running sand, the first crib which was fixed being 24 feet from the surface for a foundation for the walling to start from.

The total depth of this shaft is 250 yards, the time occupied in sinking and walling, including delays and arching the pit bottom, was 6½ calendar months, or at the rate of 9½ yards per week. On page 252 is shewn a section of the metals sunk through.

The total number of holes bored, ...	8,535
The total number of holes blasted, ...	8,535
The total lbs. of dynamite used, ...	4,293½
The total coils of fuse used, ...	1,438
The total number of detonators, ...	8,535

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PUMPING.

Much engineering skill is frequently required to contend with the water met with in sinking. Should the quantity be small, it may be drawn to the surface with the water barrel as the sinking progresses. When it reaches to 1000 or 2000 gallons per hour, a steam pump will be found a ready means of keeping the pit bottom clear of it. Should the water not exceed the quantity named, it would be better to use the above-mentioned pump, which is portable and easily removed, as required according to the progress of the work, than to resort to the usual appliance, and pump the water out by the ordinary lifting set. Above that quantity, however, the lifting set must be used. It has frequently happened that several sets of pipes have had to be used in one sinking pit bottom at the same time.

The pumps are usually hung by chains or ropes from a strong crab or crane at the surface, and are lowered or travelled as the sinking goes down, when a lowering of the pumps becomes necessary. The lengthening of the lift is done from the top by putting on another pipe 9 feet long. The pumps, while being lowered, are kept in position by means of buntons and collarings, but as the height of the lift or column becomes too great to travel it, the lift above the bucket piece is made stationary by means of strong buntons 8 in. or 9 in. square, these being fixed into the sides of the pit. The lift or column is then supported by wooden yokes 6 in. square, and bolted together under the flange of the pipe and resting on these buntons: see Plate XXV.

In this case it will be observed that instead of the ordinary cast-iron or sliding suction, which is generally in use at sinking pits, there is an india-rubber suction. It is 14 feet long and 6 inches diameter, and for pipes from 8 to 12 inches diameter. It is considered a great improvement upon the old cast-iron ones, and good work has been done with it in sinking a pit at Broxburn Oilworks. To save the suction from being damaged by shots, a small chain is used for the purpose of hooking it on to the kettle to hoist it up the shaft while the shots are being fired. After the shots are fired, the workmen descend the shaft, and fix it on again in the usual way. Time occupied taking off and putting on, about 14 minutes.

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There are also fixed on the pipes two glands: see Plate XXV., to which are attached two chains, for lowering and carrying the working parts of the column so as to get a pipe 9 feet long put on between the bucket-piece and the bottom of the column as the sinking progresses. In fixing the permanent set of a colliery for the constant drainage of the mine, it is necessary to have the lodgment for water sufficiently large. Circumstances will determine whether the set should be a lifting or a forcing one, or whether some other system should be adopted. In some cases steam pumps are placed at the bottom of the pit to force the water to the surface without the use of pump rods.

FITTING UP SHAFTS FOR WINDING.

In order to wind coal with despatch from a shaft in the most modern style, it is necessary that wood buntons or byats, 6 inches square, be put across the pit every 6 feet, and verticular guides made of wood, 5 inches × 4 inches, fastened to them, for the cages to run up and down somewhat similar to a carriage on a railway; or the guides may consist of single-headed steel rails, weighing from 50 to 60 lbs. per yard, two rails on one side of each cage, generally about 27 feet long, and bolted to wood buntons, the distance being 9 feet apart. Or it is necessary to have wire rope guides for the cages to run up and down. In all cases wood guides are applicable, except where the winding shaft is a furnace pit, in which case the wood would be liable to take fire. Where engines are well balanced, as when the winding drum is connected to two cylinders, and no hanging-on places between the bottom of the shaft and the pit bank, then wire rope guides are very applicable. The ropes may be tightened to the proper strain by a screw at the top of the pit framing, or by hanging weights to them near the bottom of the pit below the hanging-on. The ropes should so hang that there will be 8 or 9 inches space between the two cages at meetings. Ropes used for guides are made of a single strand of thick wire. Comparing them with wood, they are much cheaper and more quickly put in, and in case of a fire do not supply fuel for the

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flame. This is worth consideration. Of late years, they have been introduced into a number of shafts in this country and Germany.

The following is a description of the winding engines and winding appliances at Messrs Davis, Scott, & Co.'s Lady Windsor Pits, near Pontypridd, above referred to, and at page 250 are a number of questions, with answers, relating to the different component parts of these engines. They were made by Messrs Robert Daglish & Coy., Engineers and Boilermakers, St. Helen's, Lancashire, and are improved coupled, high pressure, horizontal winding engines: diameter of cylinders, 42 inches; length of stroke, 7 feet; engines, 25 feet centres. The valves are Cornish, with Mr George Heaton Daglish's patent cut-off. The steam valves are 12 inches, the exhaust valves 13 inches, steam pipes 11 inches, and exhaust pipes 18 inches diameter. The engine-driver has under his control an ordinary foot brake, and also, in addition, a powerful steam brake. There are also fitted up patent safety detaching hooks as a precaution against overwinding, and, after considering the great depth of these shafts, it was decided to adopt Mr G. A. Daglish's patent conical drum, 33 feet and 18 feet diameter, weighing 60 tons.

The winding ropes, 2 inches diameter, are made of the best plough steel wire for winding four tons of coal from a depth of 720 yards. The construction of the ropes is as follows, viz.:— There are nineteen wires to each strand, and six strands to the rope; the six strands are plaited round a hempen core. The gauge of the wires of each rope is No. 10½ B.W.G., and the weight of each rope is 105 cwts. The diameter of the winding shaft is 19 feet, the depth was expected to be 720 yards, but present depth 601 yards. The pit frame is built entirely of wrought iron, and was made and erected by Messrs Parfitt, Jenkins, & Co., of Cardiff. The sheaves are made of steel, and are 20 feet diameter; the cages are also made of steel, the weight of each cage and chains being 60 cwts. The coal trams are made of wrought iron, and weigh 10 cwts. each: each tram holds 30 cwts. of coal. The guides are wire ropes, four guides to each cage. The gross working load is about 245 cwts.

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FORM OF REPORT REFERRED TO IN THE FOREGOING PAPER, PAGE 243.

REPORT OF WORK DONE AT.....SINKING FOR WEEK ENDING.....DAY OF.....188

Date.	Name of Foreman.	No. of Men.	No. of Holes Bored.	No. of Holes Blast'd.	Lbs. of Dynamite used.	Coils of Fuse used.	No. of Caps used.	Lbs. of Candles used.	Gallons of Oil used.	Lbs. of Tallow used.	Lbs. of Waste used.	Commenced Walling.	Finished Walling.	No. of Yards Walled.	No. of Yards Bratticed.	Depth sunk per Day.	Remarks.

Yards. Feet. Inches.

Depth of Pit at commencement : : .....188 .

Total depth sunk since commencement : :

£ s. D.

Approximate cost per yard of Sinking .. .. .. : :

Approximate cost per yard of Walling .. .. .. : :

Approximate cost per yard for Material .. .. .. : :

Signature of.....

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PARTICULARS RELATING TO THE WINDING ENGINES ERECTED AT THE LADY WINDSOR PITS, NEAR PONTYPRIDD, BY MESSRS ROBERT DALGLISH & SONS, ENGINEERS, ST. HELENS, REFERRED TO IN THE FOREGOING PAPER, PAGE 248 :—

1. Name of place.
   Messrs Davies, Scott, & Co., Lady Windsor Pits, Ynisybwl, near Pontypridd, South Wales.
2. Thickness of metal of the frame bed.
   One and a half inches.
3. Piston ring. Do you prefer the numerous small springs to one large spring? I do not find this system of packing ring in any system but yours.
   This is a special piston adopted by consulting engineer. We prefer cast iron rings, three in a piston; large section, $1\frac{1}{8}''$ broad, $\frac{1}{2}''$ thick.
4. Air holes in piston at end of bolts. What for?
   Preferred by consulting engineer.
5. Is the nut that holds the piston secured by a cotter?
   By a sett pin.
6. What is the width of clear space at end of stroke between piston and cylinder cover?
   Three-quarters of an inch.
7. What is your factor of safety?
   Ten.
8. What is the brass made of? Gun metal or phosphor bronze?
   Best tough ingot copper and tin = to gun metal.
9. Steam pipes—thickness?
   One inch.
10. Exhaust pipes—thickness?
    $\frac{3}{4}''$ to $\frac{7}{8}''$ thick.
11. What is the object in placing the stop valve so low down?
    To clear floor line.
12. Number and general dimensions of boilers for the engine? Coal and water expected to be consumed per hour?
    Four boilers, 7′ dia. by 30′ long each, two flues. Coal and water used equal to best style of Lancashire boiler.

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13. Guide bars—thickness of metal?
    Average $1\frac{1}{2}''$.
14. Connecting rod—What quality of iron?
    Best hammered forged scrap iron.
15. Why both a key and a nut to fasten scrap pin?
    Special order of consulting engineer.
16. Is the crank shrunk on the shaft?
    Yes.
17. Is the crank pin shrunk into crank?
    Yes; and driven in with tup.
18. Dimensions of keys to fasten crank and crank pin?
    Crank key, $5'' \times 2''$; crank-pin key, $2\frac{1}{4}'' \times 1''$.
19. Eccentrics—What is the meaning of the break in the eccentric where wood is introduced?
    My patent, and is for adjusting of lead.
20. You speak of beechwood on small diameter of drum. What is that?
    For the spare rope to bed on.
21. Brake strap—Width, thickness, and material.
    $11'' \times \frac{5}{8}''$.
22. Working pressure in boiler?
    80 lbs. per square inch.
23. The lift is 700 yards—In what time?
    Present depth, 601 and 565 yards. Not yet tested for time.

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SECTION OF STRATA CROSSCUT BY NO. 13 PIT, NIDDRIE COLLIERIES, 1885, REFERRED TO IN THE FOREGOING PAPER, PAGE 245 :—

	Thickness.		Depth.		
	Ft.	Ins.	Fms.	Ft.	Ins.
Surface,	11	0	1	5	0
COAL, "Great Seam,"	4	6	2	3	6
Sandstone,	23	6	6	3	0
COAL, "Stairhead,"	15	0	9	0	0
Fireclay,	0	9	9	0	9
Sandstone,	12	6	11	1	3
Fakey Fireclay,	4	6	11	5	9
Sandstone,	16	5	14	4	2
Fakes,	2	5	15	0	7
Fakey Blaes,	4	6	15	5	1
COAL,	0	4	15	5	5
Fakey Fireclay,	1	6	16	0	11
Sandstone,	7	6	17	2	5
Fakey Rib,	0	4	17	2	9
Fakey Fireclay,	1	2	17	3	11
Ironstone Balls,	0	3	17	4	2
Daugh,	0	5	17	4	7
Fakey Blaes,	1	8	18	0	3
Blaes,	2	10	18	3	1
COAL,	0	4	18	3	5
IRONSTONE,	0	10	18	4	3
COAL,	0	6	18	4	9
Bastard Fireclay,	12	0	20	4	9
Sandstone Ribs,	7	0	21	5	9
Fakey Blaes,	5	6	22	5	3
Sandstone,	3	0	23	2	3
Blaes,	11	7	25	1	10
Ironstone Balls,	0	4	25	2	2
Blaes,	0	9	25	2	11
COAL,	2	9	25	5	8
Fakey Fireclay,	5	10	26	5	6
Sandstone,	8	1	28	1	7
Blaes Falling,	1	4	28	2	11
COAL, "Gillespie,"	7	6	29	4	5
Fireclay,	30	1	34	4	6
Sandstone,	42	0	41	4	6
COAL,	0	10	41	5	4
Fireclay,	14	5	44	1	9
Grey Fakes,	5	3	45	1	0

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	Thickness. Ft.	Ins.	Depth. Fms.	Ft.	Ins.
Sandstone,	38	10	51	3	10
Coal,	0	8	51	4	6
Fakey Fireclay,	30	4	56	4	10
Coal,	0	7	56	5	5
Fakey Blaes,	13	3	59	0	8
Coal,	4	6	59	5	2
Bastard Fireclay,	15	3	62	2	5
Sandstone,	15	1	64	5	6
Shaley Blaes,	10	9	66	4	3
Soft Daugh,	0	4	66	4	7
Blaes, with Iron Balls,	1	6	67	0	1
Coal,	3	7	67	3	8
Fireclay, soft,	3	6	68	1	2
Fakes,	20	6	71	3	8
Blaes,	9	0	73	0	8
Ironstone,	0	6	73	1	2
Coal,	1	1	73	2	3
Sandstone,	19	2	76	3	5
Coal,	8	5	77	5	10
Sandstone,	25	10	82	1	8
Fakes,	3	6	82	5	2
Blaes,	13	6	85	0	8
Sandstone,	8	0	86	2	8
Kingle,	11	4	88	2	0
Sandstone,	6	11	89	2	11
Fakes,	7	6	90	4	5
Blaes,	30	4	95	4	9
Coal,	5	9	96	4	6
Sandstone,	2	6	97	1	0
Fakes	2	3	97	3	3
Sandstone,	10	4	99	1	7
Fakey Blaes,	7	11	100	3	6
Ironstone B.B.,	1	1	100	4	7
Sandstone,	7	4	101	5	11
Coal,	6	3	103	0	2
Sandstone,	8	6	104	2	8
Fakes,	9	0	105	5	8
Blaes,	11	9	107	5	5
Ironstone Ball,	0	5	107	5	10
Coal,	0	4	108	0	2
Fireclay,	4	5	108	4	7
Sandstone,	6	3	109	4	10
Kingle,	14	3	112	1	1
Fakey Plies,	1	6	112	2	7

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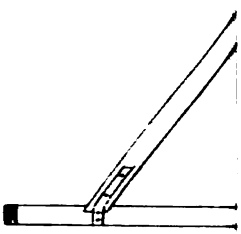

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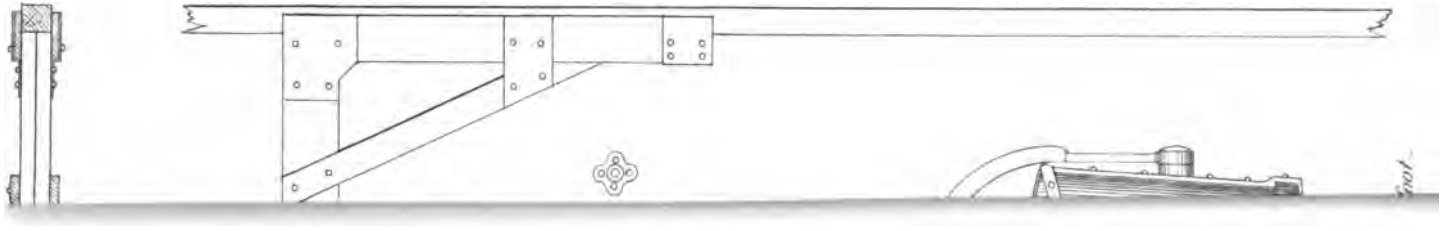
PLATE XXIII. VOL. VIII. M. I. S.

To illustrate M.r Robert Beith's Notes on
"SINKING OF SHAFTS."



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THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

HALL OF THE INSTITUTE, HAMILTON,

27th JANUARY, 1887.

JAMES S. DIXON, Esq., President, in the Chair.

Fully 30 members were present.

The Minutes of the last Meeting were read by the Secretary and confirmed.

Mr WILLIAM M'KINNELL, Clyde Steel and Iron Works, Sheffield,

was elected by ballot as an Ordinary Member.

The following discussions then took place:—

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DISCUSSION OF THE REPORT OF THE COMMITTEE ON THE COAL MINES REGULATION BILL.

Mr JOHN DRINNAN communicated the following:—I am glad to see that though Mr Begg's paper did not provoke a very lively discussion, it has produced an excellent report by the committee who were appointed to consider it. With respect to Clause 10, I entirely approve of the committee's recommendation that the clause should be so altered as to permit managers to believe, as other people are permitted to believe, that their innocence is supposed until guilt is proved. It does not appear to me, however, that the wording of the amended clause will effect this; the wording of it might still permit of it being construed to mean, that the onus of proving his innocence lay upon the manager, and, to put it beyond all doubt, the clause should be so altered as to read thus—"The owner, agent, or manager shall be guilty of an offence against the Act *if it be proved* that he has not taken all reasonable means," &c. With regard to the weighing clause, the committee have pointed out very serious evils which may arise in the future; but it is doubtful whether the checks they recommend would effect the purpose they have in view. With the facilities presently afforded to checkweighmen, I do not see how they could be prevented from taking note of every tub that comes up, and any attempt to restrict these facilities would certainly tend to still further widen what has too long been a running sore, which would soonest heal by being severely let alone. The need for some such alterations as the committee recommended on Clause 20 was recently exemplified here in England where a general manager was fined for having failed to see that some machinery underground was properly fenced; but I very much fear the deletion desired by the committee will not be granted. Rule 3, as your committee say, is "exceedingly indefinite," &c., and a colliery proprietor could only safely guard himself against its provisions by removing the fan to such a distance from the shaft as to make it utterly inefficient for the purpose it is meant to serve. Rule 4 is absurd in most of its provisions, but most of all in requiring that an inspection be "immediately" before the men commence work. Considering how injuriously

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an important industry might be effected by a too literal interpretation of this rule, there should be no hesitation—from motives of delicacy or fear of giving offence to this one or that one—about giving a frank and full declaration of opinion, and I do not see what other opinion can be formed than that the clause as it stands compels the manager to work with his head in a noose, which an inspector may at any moment tighten to his very great inconvenience, if not to his utter extinction. In saying this, I deprecate any inference from it that I am imputing to inspectors undue severity in the working of the Act. My experience of those inspectors, whom I may be supposed to know is, that they fully recognise the difference between their duties and those of an ordinary policeman, and they discharge them in the temper and spirit of gentlemen. But though this be true, it affords no reason for entrusting to them a discretionary power utterly uncalled for, as the question to which it refers could easily be made clear if all the parties whom it affects would definitely state what they want. The amendment proposed by the committee is also open to a charge of indefiniteness, and it would be better to say at once that an inspection be made not more than two hours before the men commence work.

Mr J. B. DALZELL agreed with the recommendation of the committee that the Act of last session relating to check-weighers should be repealed. Probably reasonable objection might be taken by miners to the imputation cast upon their union officials by the recommendation of the committee; and he thought that miners who do not appoint check-weighers should have what guarantee an Inspector's imprimatur might be worth in the way of securing just weight. He would recommend, therefore, that weighers and check-weighers should hold a certificate of character and competency granted by one of H. M. Inspectors of mines; and that the miners may, at their own cost, appoint in writing a certificated weigher (who when so employed shall be termed a "check-weigher") to take an account of the mineral gotten only by those so appointing him. The certificate of a weigher or check-weigher should be cancelled on its being proved to the satisfaction of the Court that the holder of such certificate has—(*a*) impeded, interrupted, or interfered with the working of the

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mine; (*b*) or interfered with the freedom of the workmen employed therein; (*c*) or interfered with the weighing; (*d*) or divulged information as to the hours of working of any person or persons employed therein; (*e*) or conducted himself to the detriment of the owner, agent, or manager; (*f*) or divulged to any person other than the owner, agent, or manager, or their deputies, or to a workman himself, information relating to the weight of any mineral gotten by said workman.

Mr R. T. MOORE said that while he was one of the committee which drew up these recommendations, he was sorry there was a number of meetings at which he was unable to be present, and there were some points in the report which he should like to make a few remarks upon. The first was at page 208 where objection was taken to the owner, agent, and manager being held guilty of an offence against the Act unless he proved he had taken all reasonable means to see that it was carried out, and it was said this was a reversal of the fundamental principle of our laws that a person be considered innocent till he be proved guilty. When one considered this carefully it was not such a very great violation of the spirit of the law as it would seem to be at first sight. In considering the Mines Regulation Act, one must take into account that it had reduced the number of accidents. Its effect, therefore, had been good. Like all other acts which interfered between employer and employed, it must be enforced by the owner. No one else could enforce it but the owner, agent, or manager, and, therefore, Parliament made it the duty of the owner, agent, and manager to see it carried out. If there was an offence committed against the Act, the owner, agent, and manager were to blame because they had not done their duty in seeing the Act carried out, unless they could show that they had taken all reasonable means to do so; in the same way as the captain of a vessel would be to blame if he did not see that the look-out attended to his duty. It might not be out of place if he read the opinion of a judge on the Queen's Bench about the duties of the owner, agent, and manager in the case of Corfield *v.* Evans which was heard on the Queen's Bench Division on 8th July, 1886 (reads).* This was

* This case, which arose out of an accident caused by unfenced machinery, and in deciding which the Judge commented at considerable length on the individual responsi-

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the opinion of Mr Justice Wills, and it was entitled to very great weight. He did not think they would be able to alter the Act on this point, because any alteration of this would practically be repealing the whole Act. The rule was no great hardship he thought, for any one going into the coal trade knew what responsibility he was undertaking. He did not think there was very much chance of the committee's recommendations as to check-weighmen being adopted, as the Act was now passed. It seemed fair that the colliers should appoint anyone they pleased, whether he was an official of a trades union or not, to check their weights, and in all these matters the minority had to be ruled by the majority. The minority had to pay their taxes, even although they objected to do so. Then the committee had taken exception to the general rule about furnaces. He did not think any such alteration as they suggested was necessary. People did not often put in furnaces now-a-days, but if they did there were three alternatives, and it would always be practicable to properly mix the air so as to comply with the rule. Then as regarded the mechanical ventilators, he did not think the proposed alteration met the case, because fans had been seriously damaged, even in Scotland, although not immediately over the shaft. The rule was, in his opinion, a very good one as it stood, and it would be quite practicable to place a fan in such a position that it would not be injured by an explosion. As to Rule 4, there did not seem to be any great difficulty in the way of appointing a fireman in writing. Most people were able to write, and it was simply the trouble of writing out his appointment. There was very little in the objection that the fireman might be absent. In such a case a spare man had to make the examination, and he might be appointed in writing. He did not see that there would be any practical difficulty in carrying out the rule. It was a small matter altogether, and not worth objecting to. The committee seemed to think there were fewer accidents in mines examined with naked lights than in those examined with locked safety lamps. He did not know that facts would bear that out. The rule making the use of safety lamps

bility of the owner, agent, and manager), is reported in the *Colliery Guardian*, 16th July, 1886, and the *Iron and Coal Trades Review*, 24th Sept., 1886.

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compulsory upon mines in which gas had been found within the previous three months was a very good one. It would put an end to that large number of trifling explosions, such as a man getting burned by gas at the face of the brushing, etc., and would do a great deal of good. He thought the committee's suggestion that mines worked with naked lights were freer from accidents from falls of roof than those worked with safety lamps was quite untenable. The mines of Durham, which were worked wholly and inspected wholly with safety lamps, were much safer than those of Scotland which were worked and inspected with naked lights. The committee's alteration would practically leave the decision of whether a mine should be worked with safety lamps or naked lights in the hands of the Inspector, and he would never take the responsibility of saying that it should be worked with naked lights. There should be nothing left to the discretion of the Inspector. The next point was as to gunpowder. The committee said that mines would have to be abandoned if this rule was carried out. As a matter of fact, this rule was being carried out every day in this district. There were places where no shots were fired when the men were in the pit, and there was no great difficulty in carrying it out. The shots were prepared, and men went down at the change of shifts to fire them when nobody was in the pit. At anyrate, he thought it should be kept out of the recommendations that mines would be abandoned if it came into force. As to the rule about having props every six feet, he thought it was a very good one. It did not say they were all to be six feet apart, but there was to be no place where the distances were to be more. It would not necessarily cost more, because the props could all be drawn when they were no more needed. Accidents did not happen where people knew that the roof was bad, but where it was thought to be good. Many accidents would be prevented by timbering at regular intervals. Accidents happened from the roof breaking off from an unseen joint or "lype," perhaps behind the coal which was holed. If props were put up at regular intervals there would be a better chance of preventing accidents of this class. It was seen where there was a definite system the number of accidents was smallest.

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In South Staffordshire, there was a special rule setting forth that props were to be put up at fixed distances, each manager being left to fix the distance he considered advisable for his particular colliery. One seam might require not less than 4 feet, and others not less than 6 feet. This rule had been found to work extremely well, and the consequence was that while previously the percentage of accidents was very high, the district now stood about the same as Durham. No doubt, if such a rule were passed, it would tend to lessen the number of accidents.

Mr JAMES ANDERSON said he concurred very much with what Mr Drinnan had said in regard to this clause 10. As it stood in the present Act, and as it might perhaps be put into the new Act, he thought for himself that this was an exceedingly offensive provision. As had been stated by the Committee, it was a fundamental principle of law that every person must be held innocent until proved guilty. It was reversed in the case of the Mines Act, and, with all due deference to Mr Moore, he did not think the opinion he had given had anything to do with the provisions of this and similar clauses in the proposed new Act. Under the Mines Act and the Factory Act, there were certain statutory duties laid on owners and managers, and if they failed in them, they were guilty of an offence against these Acts. For instance, if any of the special rules were neglected by the manager, or if he failed to see them carried out, which was *his* duty and no other person's to see done—if, for instance, he failed to fence a dangerous piece of machinery, that was an offence under the Act, and it became the duty of the Government to see that he was brought to account. The case read by Mr Moore simply and in his opinion justly affirmed the principle that no one, however busy, could relegate *his own particular duty* to another without being responsible and liable for that person's default. In the case under clause 10, and others, it was very different. The owner, agent, and manager were each to be guilty, not of their own default, but of that of another in his particular duty, and on whom also a statutory duty was laid. unless the owner, agent, and manager prove, &c., even although he had taken due precaution to have that duty done. He

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thought the correct way to bring the thing home was to cite a case that had occurred. He knew a case where a manager was prosecuted for failing to prevent a collier taking an iron stemmer or pricker down the pit, and although the man that did it actually confessed that he had concealed it in the leg of his trousers, the manager was subjected to the annoyance and expense of a lengthy prosecution. The prosecution broke down, and he thought justly so. He thought, with the Committee, that the alteration proposed by them, did not involve much in the wording, but a good deal in the principle. It was quite right, if the manager had failed in his own duty, if he had failed to see that the Act so far as laid upon him could be carried out, he should be held guilty of an offence against the Act, but he should be held perfectly innocent until those to whom he is responsible had proved he had failed in doing his duty. There can be no good reason why a man on becoming a colliery owner or manager should thereby be put outside the law that protects every other one, even the meanest, of Her Majesty's subjects.

The PRESIDENT said the subject was discussed at great length by the committee, which was large and representative. It should not be necessary that the owner, agent, or manager should have to prove that he had taken every precaution. The onus of proof should lie on the prosecutor, which, he thought, was a perfectly fair thing. He did not think it was for him more than any other member of committee to vindicate the report. As he had said, every clause of the Act was taken up and discussed at great length, and Mr Moore was present at a number of those meetings, and had the proof of the report sent him for revisal before it was finally adopted by the committee. It was at these meetings of committee those objections should have been raised. They had not heard a word of them till now. If they had been raised at the proper time they would have been fully discussed and thrashed out; but he felt, after the committee, of which Mr Moore was a member, had taken all this trouble, and had made recommendations which they proposed to bring before the Home Secretary, that it was hardly fair that Mr Moore should now come there and object to the most essential points of their report. He

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did not wish to go into the different matters which had been raised, as that had all been gone thoroughly into and reasons for the committee's findings were shortly but clearly given in their report. Many members, who were not now present, were on the committee from Fifeshire, and those were the parties who chiefly brought up the question of inspection by naked lights. They maintained that, having no fire-damp in their mines, a great many of those rules were unnecessary in their case. In regard to using explosives in mines, Mr Moore seemed to think it was a matter very easily arranged to withdraw the men; but, he said advisedly, that it would lead to the abandonment of mines, because in many of the clay-band, ironstone, limestone, and shale seams it was necessary to fire shots every few minutes, and fire-damp was occasionally found in such mines, which should bring them within the meaning of this clause. It would not be possible to work them if it was necessary to withdraw the men as was proposed. Some of the recommendations in the committee's report might be of more importance than others, but still he thought, as a whole, they were judiciously stated, and none could be considered unnecessary. In regard to dusty mines, he would go further, and say, if shots were fired in main roads where there was dust, this should only be done by some means such as the water cartridge, whereby flame would be quenched. He thought that would be a very necessary precaution to take in such circumstances.

Mr R. T. MOORE said, with regard to the President's remarks, he was not present at any of the committee meetings after the discussion on the check-weigher took place, and while he had been present at the discussion about the responsibility of the owners, he had not then in his possession the report of this case, which he thought might be of interest to the members. He did not wish to set his opinion above that of the wisdom of the multitude of councillors in the committee, but he thought he was entitled as an ordinary member of the Institute to express it.

Mr DAVID ANDERSON said he quite agreed with the President's remarks in regard to the difficulty in working ironstone pits under the condition stated. It applied to coal as well as ironstone; but, in the first place, in referring to ironstone, he had known a pit where

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fire-damp had not been seen for two or three years, and where a small quantity was got from a break in the roof sufficient to show it was there. He supposed, if this rule were applied in the way it would be applied if the proposed bill was passed, viz., carrying it out in the strict letter of the law, that that pit would have to be brought under the regulations of not firing shots until all the men were out of the mine. If it would not have led to the abandonment of the pit, it would have led to its being worked at least at such increased cost that it would have been a practical abandonment, because every two men were firing from three to four shots a day, and in a pit that was putting out 300 tons iron-stone it took a great many shots to produce that quantity. He thought in that case it would be an excessively serious matter if this part of the Bill became law. He thought it applied also to coal workings. Take the case where there was a mine or two driving, and they were all on the same level. The mine might either be going to the rise or the dip; it got its air from part of the same current as the rest of the coal workings. They might need to fire ten or a dozen shots during the hours the ordinary workings are going on; and if the men were to be withdrawn at the firing of each shot it would lead to the stoppage of that part of the workings. There might be a water, lime, or other appliance that might be suitable whereby the shots might be fired without the men being withdrawn. He did not know whether these cartridges had yet got the length of being applicable to all classes of mine driving, but, as he had said, it would be a serious thing if the men had to be withdrawn from the pit while the shots were being fired, and he thought the committee were just within touch of being right, if not right, in saying it would lead to the practical abandonment of some of the pits. He perfectly agreed it would he a great hardship if this part of the Bill became the law of the land. As to the other matter refered to about the owner, agent, or manager being held innocent until proved to be guilty, he thought there was a great deal of force in this, and although the opposite of this might be the law at present, that was no reason why they should not attempt to get it repealed if within their power to do so.

Mr SMART said, in reference to Mr Moore's statement, that the

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complaint against the proposed Act was, that the owner, agent, and manager were each to be held responsible for any infringement of the Act (no matter by whom committed), and all the three would be tried for the one offence; the Committee's proposal was to alter this part of the different clauses, so that the owner, agent, or manager would be held guilty of an offence against the Act if it was proved that he had not taken all reasonable means of enforcing its provisions. What the Committee wished was that only one of the three could be held liable to be prosecuted for the same offence, and that he be considered innocent until proof of guilt was established against him.

Mr GILCHRIST said, in connection with shot firing, that the Bill in no way provided for water cartridges. He thought that had possibly been overlooked; and it left water cartridges under the same restrictions as ordinary powder.

The PRESIDENT—The Bill alludes to it in one place :—"Unless the explosive is such as not to inflame gas."

Mr JAMES GILCHRIST said, as to the employment of boys underground, it was part of the old Act that they could not employ a boy on the surface fifty-four hours a week until thirteen years of age, while a boy between twelve and thirteen might be employed fifty-four hours underground. It seemed contradictory, and it was to him rather curious, that while they could employ a boy fifty-four hours underground, they could not employ him more than thirty above ground.

Mr ROBERT WADDELL supported the Committee's recommendation in regard to the working of ironstone and the firing of shots. One point was very important, viz. :—In some ironstone workings with bad roof and heavy redd, if the shots were not fired very soon after the material was prepared, by the time they removed the workmen and brought others to fire shots, they would often require to commence the work of redding away the refuse anew. There was another point, in regard to the examination with an open light, would it not be the case that it would be too efficient for the safety of the men examining with it? He thought the examination, as regards ventilation, ought to be made with a safety lamp.

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The PRESIDENT said the Fife members brought this point up very strongly, and they said they had no fire-damp.

Mr DAVID ANDERSON said that the roof would be better seen with a naked than with a safety lamp.

Mr ROBERT BEITH, in reference to Mr R. T. Moore's remarks as to the ventilating fan, said he would like to know if there was any definite distance from the pit at which he would consider it safe?

Mr DAVID JOHNSTON said distance was not in the question at all.

Mr A. M. GRANT said there had been a serious explosion in South Wales, where there were several lives lost, and great destruction done to the shaft; and the fan, which was made by a Kilmarnock firm, although almost over the pithead, was not destroyed. Whether that might be an exceptional case he could not say.

Mr F. J. ROWAN said, in working with mixtures of gas and air for producing high heat for welding, Mr Sutherland, whose name was perhaps known to the members in connection with Gas Producers, had studied the subject of explosions, and he found he was able to design a form of explosion valve which never failed to act if placed at any bend or angle in the gas mains; the force of explosions having been found to pursue straight lines. Some such means might very readily be adapted for protecting ventilation fans. But that did not at all affect the recommendation of the Committee. It left the question of the distance between the top of the shaft and the fan an open question.

Mr ROBERT BEITH asked Mr Grant if he could state the distance of the fan he had referred to from the top of the shaft.

Mr GRANT said he could not. He might say this much, in regard to the remarks of Mr Rowan, that in a great many works worked with explosive gas, such as iron works, it had been a regular practice to have explosion valves fitted at the ends of the tubes so as to allow, in the case of an explosion, the gas to escape, and the tubes were in no way injured.

Mr R. T. MOORE said that in many of the Welsh collieries the top of the up-cast was very lightly covered. He should think some such idea as that was in the minds of those who framed the clause.

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Mr GILCHRIST said if they could be sure that that was the intention of the framers of the Bill, it would have relieved a great many of their minds, because many fans were built in that way. The danger, if this Bill became law, was that the fans at present in existence would require to be altered to meet its requirements, and it would be rather a serious question; but if the suggestions made would overcome the difficulty it would be a very simple matter, and he thought the Institute would be at one with the framers of the Bill.

Mr JAMES ANDERSON said a case had been cited where the shaft was covered, and there was an explosion at the fan.

The PRESIDENT said it was not in the fan, but in the fan drift. If it was laid down that the fan must be a specified distance from the pit-head, the difficulty was that many fans doing useful work would require to be removed. At most upcast pits there were movable covers on the top which rested in the direct line of an explosion. His own experience was that a fan a good distance back did not seem to make much difference, and that was shown in a case in which the upcast shaft was tightly covered with brattice fastened down with brattice nails. The brattice boards gave way, but sufficient force went along the fan drift to cause, at a distance of about twenty yards from the pit-head, the top to be blown off. Therefore he did not see that distance was a matter of so much importance, but probably some plan of valves might be devised as was done at ironworks.

The SECRETARY said in committee they had long and lively discussions on all the points. He did not agree with all their recommendations although he was a member of committee and present at all the meetings. It was impossible that any committee could be absolutely unanimous on almost any question, but this report was the outcome of their discussions, and the recommendations were carried by a majority of the committee. He might say in no case was there a division taken, the feeling of the majority in all cases being so evident that there was no necessity for taking a vote, although, as he had said, there were a few unimportant points he did not personally agree with.

The PRESIDENT, in adjourning the discussion, said that means were to be taken to bring the report before the authorities.

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DISCUSSION OF MR GILCHRIST'S AND MR GRANT'S "NOTES OF TRIALS WITH SETTLE'S GELATINE WATER CARTRIDGE."

The SECRETARY read the following communication from the Manager of Nobel's Explosives Company :—

"At last meeting Mr Bonser promised to give some idea of the proportion which the gases resulting from the explosion of gelatine-dynamite bear to each other, and we have now pleasure in giving you the following figures, which closely represent the exact proportions, viz. :—

CARBONIC ACID, ...	60%
VAPOUR OF WATER, ...	22%
NITROGEN, ...	18%

"We observe that (in p. 117) the strength of the No. 1 Battery, which we supply, is given at 1·2 volts, but this is an obvious error. The figures should be 120 volts."

Mr GILCHRIST said the information as to the 1·20 volts was supplied by Mr Taylor, consulting engineer to Nobel's Explosives Coy., but it appeared now that 120 was the correct figure.

Mr F. J. ROWAN said the information given about the composition of the resulting gas was not a bit more satisfactory than the chemical equation which he referred to at last meeting. In fact, it was simply that equation put into percentages. It did not give them the actual composition of the gas that had been found to result from the explosion, but what theoretically ought to be produced by the decomposition of the nitro-glycerine. As to the other point, he should say, from the extremely small quantity of electricity produced by such a machine, that 120 volts certainly was nearer the mark of the tension of the current than 1·2 volts.

The discussion was closed with a vote of thanks to Messrs Gilchrist and Grant.

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DISCUSSION OF MR ROBERT BEITH'S "NOTES ON THE SINKING OF SHAFTS."

Mr RALPH MOORE said Mr Beith's paper was another of those very excellent papers which the Institute had brought forward from practical men. It was a record of certain facts which brought out very creditably the work done. There was nothing very new in it, except that whenever they set a man down to do a thing, and he set his mind to do it well, he generally did it well. It was exceedingly creditable to Mr Beith to write such a description, the materials for which he had got for them, and creditable to his brothers to have carried on the sinking in the way in which they had done—going at their work in a systematic way. Everything done there had been done before, but not done with so much system. There were many points which they might all take note of and improve by. He had had great pleasure in reading the paper. They would observe that the pits described were round pits. It seemed to be the quickest mode of putting down shafts, and the mode of making them safe,—the brickwork,—was done in a very systematic way.

The SECRETARY asked if Mr Beith would be so good as to tell them if the section of the strata on p. 252 was measured in the line of the pit or at right angles to the seam? It was well known that the Niddrie seams lay at a very high angle.

Mr ROBERT BEITH said the thicknesses were taken vertical in the line of the shaft.

Mr RALPH MOORE said he might say of this sinking, he paid great attention to it while it was in progress. About the Great and Stairhead seams they had very great difficulties to encounter. They went through waste, and it was not very easily managed. They would see that he had put the Stairhead at fifteen feet. He thought it was not that thickness.

Mr BEITH said he might also remark regarding the statement at the bottom of page 245, that the six and a half calendar months included two weeks in which they were employed breaking the door-heads at the bottom.

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Mr GILCHRIST said at the foot of page 242 and top of 243, Mr Beith mentioned an apparatus which his brother had patented for pit and shaft sinking; was it used at Niddrie?

Mr BEITH—No.

The PRESIDENT said somewhere in his paper Mr Beith mentioned that he had found great advantage from using Newall's ropes with the right and left strand. He would like to know the circumstances under which those ropes were used, because his experience with that kind of rope was quite adverse. The circumstances may have been different from Mr Beith's case as the drum and pulley were only about five feet in diameter. They tried three or four non-twisting ropes, but every one untwisted and had to be taken off.

Mr BEITH said it was at Spittalhall while sinking from the Main to the Splint coal that they used the rope. They had got a new plough steel rope, he thought 250 fathoms in length, one inch and a quarter diameter. It came from Haggie Bros., and did not open out, but spun so round that it was apt to throw the men out of the kettle. They wrote Messrs Newall, who sent a rope, which they termed their right and left hand twist, and after it was put on it went round only a few turns. It was perfectly non-twisting.

Mr PITCAIRN said he had experience of a non-twisting rope by D. H. & G. Haggie, which worked quite satisfactorily.

The PRESIDENT said he thought it was a pity, when Mr Beith was writing this very admirable paper, he had dwelt so much on sinkings out of the locality and given them so many English terms. He might have confined himself more to his experience of the district, where he had been connected with some of the deepest pits that had yet been sunk. In lining pits he had often thought that concrete would be found very serviceable instead of brickwork. He had determined, if ever he sunk a round pit, to line it with concrete, using a folding frame that could be lowered down the pits. Mr Beith, in his chapter on pumping, gave some information about lowering the pump sets with ropes or chains, and gave a sketch of a very good plan of putting on a pipe where an india-rubber suction was used. In his experience a slide pipe placed above the bucket and clack doors was a very good arrange-

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ment, as in changing a bucket with heavy water there was the height occupied by the suction clack piece and working barrel to come and go in before the water rose.

Mr PITCAIRN showed and described a sliding suction he had used.

Mr BEITH said the flexible suction pipe did not suit in all cases. With pumps from 9 to 12 inches diameter it worked very well. Fifteen years ago he sunk a shaft in the Shetland Islands with one on all the way, 40 fms. It was never taken off, and was as good at the finish as at the beginning.

Mr GILCHRIST suggested that Mr Beith might give some information in connection with the Spittalhill sinkings, especially in going to such a depth, whether any precautions were taken with wood barring, and he might also give some particulars as to the pumping.

Mr BEITH said in sinking Spittalhill from the Main to Splint, they barrelled all the water. Above that they had only three lifts of pipes, and the water was pumped from the 150 fathom lodgment to the surface. Owing to the depth, they introduced a kettle rider, and he believed but for that they could not have got on, owing to the vibration of the kettle from side to side. As to the wood, there was nothing particular. It was wooded in the usual way.

Mr RALPH MOORE said he should like, as they had Mr Beith's brother there, if he would give them some idea of his conversion from rectangular pits to the round ones.

Mr ANDREW BEITH, in reply, stated that he could sink the one form as well and as fast as the other. The only circular one he had sunk was the one at Niddrie referred to in his brother's paper. At Broxburn Oilworks he commenced on 26th December, 1885, to re-sink a rectangular shaft 156 yards from the surface, and it was completed on the 6th July, 1886. A distance of 18 yards below the position of the Dunnet Shale seam had been reached. The depth sunk in that time was 164 yards, making the total depth from surface 320 yards. The average sinking without pipes was 10 yards per week. The above time included making a lodgment for water and putting in two lifts of pipes.

Mr RALPH MOORE—From which we may conclude that the one is as good as the other.

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Mr A. BEITH—The one is as good as the other if you have not the stuff to send away.

Mr GILCHRIST said he thought there could not be any doubt the round pit had the advantage in the way of going down quickly. He remembered at Earnock being struck with the two shafts there. The one was 7ft. wide inside the barring, and the other 8ft. In the largest shaft they sunk more quickly, and could always cut the sides better. In the other they wasted the sides very much, and it was some time before he discovered it was due to the narrowness of the pit. He made up his mind then that a pit of large size was sunk more quickly than a small one, and that a round pit would be sunk more quickly than a rectangular shaft.

Mr ROBT. BEITH said he had also sunk a round pit, and he found they could sink one as quickly as a rectangular shaft. As they lived in a very fast age, and things improved, they need not be surprised to hear of the bricklayers building while sinking was going on.

Mr JAMES ANDERSON—The President had remarked that concrete would facilitate work in a round pit. In this he agreed. It filled up all spaces, and was building and packing in one. It would also keep back considerable feeders of water. Concrete was not half enough used, and could be put in with unskilled labourers. In closing an old shaft lately he put in a concrete arch to prevent a surface feeder of about 170 gallons of water per minute going down the shaft and finding its way to the present pumping pit. It was perfectly successful, and was now resisting the pressure of a head of 80 feet of water.

The discussion was then adjourned.

Mr F. J. ROWAN read the following paper on "Applications of Electricity to Mining Operations :—

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APPLICATIONS OF ELECTRICITY TO MINING OPERATIONS.

By F. J. ROWAN, C.E.

THERE are several advantages inherent to the electrical method of transmitting power which render it very suitable for mining operations, and the writer believes that its employment on a general scale depends mainly upon the existence of greater familiarity with it among those who are engaged in directing or superintending mining operations.

It is with the view of contributing to this more intimate acquaintance with electrical methods of working that he has compiled the following information as to the various installations which have been actually carried out, in order to present a short account of them to this Institute.

A description of the various installations of electric lighting in mines does not come within his design in the following paper, but members may be reminded that this application of electricity has been successfully introduced in the following collieries:— Cannock Chase,[1] Eppleton Colliery[2] at Hetton Hall, Cymmer[3] and Risca[4] (S. Wales), Earnock,[5] Low Moor,[6] at Heinrichs-Glück[7] Colliery in Peterswald, and at Miesbach and Hausham[8] in Bavaria There are no doubt other collieries similarly equipped on the Continent of Europe and in America, allusion being made to some of these in Trans. American Institute M. E., Vols. VI., VIII., and X., &c. The writer's friend, Mr J. G. Lorrain, is about to carry out the lighting of an extensive mine in Africa on what is a new system in electric lighting in mines, viz., by means of secondary generators or distributors.

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1. Brit. Assoc. Reports, Section G, 1886.
2. Trans. N. of E. Inst. M. E., vol. 34.
3. *Ibid.*
4. Rep. of Royal Com. on Acc. in Mines, 1886.
5. Trans. Min. Inst. of Scot., vol. iii., p. 145
6. Jour. Iron and Steel Inst. ii. 1885, p. 553.
7. *Ibid*, p. 579.
8. *Ibid* ii. 1884, p. 639.

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The following are the instances of electrical transmission of power in mines, which will be quoted :—

(1) *Pumping*, in Trafalgar Collieries, Forest of Dean ; and at Thallern Colliery, on the Danube.

(2) *Winding*, Experiments carried out at Trafalgar ; at the Thibaut shaft of the Société Anonyme de St. Etienne ; at Pèronnière Colliery ; and at Blanzy mines.

(3) *Haulage*, at Zaukerode Pit, near Dresden ; and at Beuthen, in Upper Silesia.

(4) *Ventilation*, at Zaukerode ; at Trafalgar ; and at St. Claude, near Blanzy.

(5) In order still further to illustrate the subject, the following applications illustrating generally the transmission of power electrically will be referred to :—

(a) The experiments of Marcel Deprez at Creil, Paris, Munich, &c.

(b) Pumping carried out at St. Elizabeth and La Sorme.

(c) Electrical working in the cannon foundry at Bourges.

(d) Application of electricity to mining in New Zealand.

(6) Some data will be given by means of which a comparison between various systems of transmitting power may be instituted.

I. PUMPING.

At Trafalgar Collieries.—This application has been described by Captain Blanch Brain, who says it was started in December, 1882.

"The water to be lifted," writes Captain Brain,[9] "drains to a hold in the rocky seam of coal, which is situated about 500 yards distant from the bottom of the shaft and 90 feet vertically below it, midway between two incline engine planes, but in the seam of coal above them. Although the quantity of water is small, the position is out of the way and difficult to connect with any existing power, as the workings descend over a distance of 1000 yards beyond, the lowest point of which is 200 feet vertically lower. This made it a matter of importance that the water should not be allowed to follow down."

After going into the cost of working by compressed air and discarding the Warner's horse-pumps which had been used, the method adopted was to employ a siphon, the longer leg of which

9. Proc. S. Wales Inst. of Eng., vol. xiii. No. 5.

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carried the water to the most convenient point for it to run to a pump about 800 yards farther down the workings, where the electric motor was fixed. This electro-motor was a small one—similar to a Gramme machine—weighing 2 cwts. and 40 lbs., and "capable of giving nearly 4 horse power with a suitable current." Captain Brain does not say whether he means electrical or brake horse power, but the writer supposes he means the former. The pump was double-acting, 5in. dia. 8-in. stroke, mounted on a cast-iron base, with spur wheel gearing, and a 4ft. pulley for a belt. Two Gramme dynamo machines of size A were provided for generators, but one was found to be sufficient for the work. The electrical cable between the generator and the motor consisted of a strand, ·36in. dia., of 19 wires each ·072 in. dia., insulated with india rubber, and sheathed with lead pipe. Its length was 1000 yards, and its electrical resistance ·313 ohm. The cable was further protected by being laid in creosoted wooden boxes, 3ins. by 4ins., which were secured to the side of the shaft and to the roof of the travelling road. The total cost of the installation was a little over £250. In addition to the above appliances, an ammeter and a volt-meter were placed near the engineman, and telephones and electric signal bells were fixed in the engine-room above and in the pump-room underground. These instruments gave all necessary indications of the working of the electrical apparatus, and enabled each stroke of the pump to be heard or signalled so that the actual quantity of water being lifted could be known in the engine-room. The engineman could start or stop the motor from the engine-room, so that it and the pump could be kept locked up, and opened only for oiling. The engine and generator were fixed on the surface, not far from the top of the shaft, which was 200 yards deep, the pump being nearly 600 yards distant from the generator. A small shunt wire from the cable was connected to two incandescent lamps—one at the pump and one in the engine-house, which, consuming a small amount of power, served both for lighting and as indicators of regular working. It was found that a current of 15 ampères and 100 volts potential, or 1500 Watts ÷ 746 = 2 horse power, was sufficient for the work of pumping. The pump threw a gallon of water per stroke, and could be driven at 60 to 70 strokes per minute.

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After a long period of successful working with this plant, it has been decided to fit up electrical machinery on a larger scale, which has not yet been started. The following note, however, has been supplied to the writer by the courtesy of Mr Frank Brain, manager of the Trafalgar Collieries through Mr Radcliffe Ward (who as engineer to the British Electric Light Co., the owners of the Gramme patents, was associated with Captain Blanch Brain, and lent him some Gramme machines used in his original experiments): —"The present installation for pumping here is about 900 yards from the engine-house, where the generator is fixed at the surface; is lifting about 90 feet, maximum quantity 34 gallons per minute. We are also driving a 6ft. fan in the underground workings from the same engine-house, at a distance of about 1500 yards from generator. The new installation which we are now putting down will be about 1900 yards from the generator in engine-house, and will lift 100 gallons per minute 300 feet."

At *Thallern Colliery, on the Danube*[10] an electro-motor and pump have replaced a steam pump, which was placed at the end of the main road, 900 yards from the shaft, the depth of which is not stated. After several months satisfactory work, it was found that a considerable saving in coal was effected, and that the temperature of the pit was reduced 14 degrees by the use of the electrical arrangement. The atmosphere of the mine had been rendered unbearable by the steam pump. Details of this installation are not published, but these main facts merely have been stated.

II. WINDING.

Early in 1881 Captain Brain made some interesting experiments in winding by an electro-motor, which may be quoted. He constructed "an incline plane of 1 in 6 with ordinary colliery rails, and of the same gauge as in the works, viz., 2 ft. 7 in. One of the colliery tubs was placed on this plane, the tare of which was 7 cwt. 2 qrs. 14 lbs., having a load of castings 2,898 lbs., making a gross weight of 3,752 lbs., and constituting a working load equal to 1 ton 5 cwt. of coal nett,

10. *Oesterreichische Zeitschrift für Berg. und Hüttenwesen*, vol. 32, p. 182. Jour. Iron and Steel Inst., i., 1884, p. 223.

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this being above the maximum weight and combining as far as possible the same conditions of friction and other elements per tub as were met with in his underground workings. The winding apparatus at the top of the incline consisted of a drum 2 ft. in diameter, with two sets of spur gearing at 3 to 1, making 9 to 1, with a pulley 4 ft. diameter for a belt, the driving pulley of the electro-motor being 5 ins. diameter. A light wire rope was attached to the drum and to the tub." The winding apparatus and the spur gearing were much too heavy for the work and added unnecessarily to the friction, but no allowance was made for this in the numerical results, the gross being taken 3,752 lbs. × 7 ÷ 33,000 = the horse power for every 7 ft. vertical in 1 minute. The number of seconds required to attain the 7 ft. vertical rise was carefully noted by a stop watch, and after some weeks the electrical working was so controlled that the motor, which was the one afterwards applied to pumping, raised the load in 12 seconds, this being equal to 3·97 horse power exerted, or nearly 2 horse power for each 1 cwt. of weight of motor, or in other words equal to a colliery winding engine weighing only 66 lbs. for each H.P. it exerts. Since this result was obtained, in March, 1881, the efficiency of electro-motors has been considerably increased, so that better results can be obtained now.

As illustrating this point, the diagrams may be referred to here. Plate XXVI., Fig. 1, illustrates the Gramme dynamo machine in one of its forms, and Fig. 2 shews the winding of the ring armature and the distribution of magnetism in it during its revolution. Figs. 1, 2, and 3, Plate XXVII., shew some of the different systems upon which the winding of dynamo machines and motors may be arranged. I am indebted to Mr Sydney F. Walker for the use of these diagrams. Figs. 1, 2, and 3, Plate XXVIII., illustrate a modern form of motor which has so far proved superior to most of those which have been made. It is the motor of Mr Moritz Immisch, who has kindly sent these illustrations, and some notes about his motor. Mr Immisch has departed from the ordinarily received ideas on the subject of motor construction. He does not admit that the best dynamo is necessarily the best motor; but while admitting fully the theory of reversibility, he says that an

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efficient dynamo must from the nature of things be an inefficient motor. The dynamo in ideal has an enormously powerful field and a very weak armature, or in other words the magnetic moments of the field and armature are as widely different as possible. This principle is carried out fairly well by all the best dynamo makers. Mr Immisch has, however, pointed out that the motor should have an armature and field with relatively equal magnetic moments—that is to say that the armature and field should do equal work. This result can only be obtained by making the armature much larger in proportion to the total weight of the machine than is considered advisable in a dynamo. Strong evidence that this theory of motor construction is correct is derived from the high efficiency which the Immisch motor gives—an efficiency very nearly double that of motors made on the dynamo type. On a recent occasion an Immisch motor was tested against one of these others by a well-known maker, when it was found that for the same work the Immisch motor used exactly half the current at the same E.M.F., thus giving double the efficiency of the other, and causing the commercial cost of the power developed to be reduced by one-half.

Another point of great importance upon which Mr Immisch lays considerable stress, is that in his motors there is an absence of what is technically called "lead." From this it results that the motor may be run at any load within that for which it is designed without the brushes being adjusted and without sparking. The importance of this can readily be estimated for all cases in which the load varies rapidly.

This fixed position of the brushes is arrived at by a special method of winding the armature, which is applicable to either drum or cylinder armatures. The drum type is used for low tensions, and the cylinder for high tensions or extra low speed. The coils of the armature are so connected to a commutator of suitable construction that the coils lying along the diameter joining the brushes are cut out of circuit by being closed on themselves. (The coils thus cut out are shown in heavy lines on the diagram, Fig. 3, Plate XXVIII. The general appearance of the commutator and the method of coupling the ends of the coils are also shewn.) The reason for

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this construction is that these coils, if active, would tend to induce poles in the armature at right angles to the axis of magnetism. This would weaken both the armature and the field, because in the motor the field and the armature tend to mutually strengthen each other. The chief advantage gained by this arrangement of coils is that the resultant axis of magnetism is formed beneath the short circuited coils, and induced currents in these coils tend to keep it in a fixed position.

By following out these principles of design, Mr Immisch has succeeded in producing a motor, which with reference to weight, power, efficiency, or durability, is most successful.

The diagrams, Figs. 1 and 2, Plate XXVIII., shew an elevation and longitudinal section of a 6-inch Immisch motor. Its weight is about 350 lbs., and it will give 8 brake H.P. at a speed of 1400 revolutions per minute. The efficiency, as tested by a Prony brake or dynamometer, averages 85 per cent. between 4 and 8 H.P.

The efficiency of these machines ranges from 70 per cent. in a 1 H.P. motor to 90 per cent. in one of 20 H.P. Measured by what is technically called "torque," which is the effort exerted to cause rotation, they show a very large amount of power in proportion to their weight. Mr Immisch's electrician informs the writer that a machine of the same size as is shown in Fig. 2 Plate XXVIII., will lift and maintain at its normal torque a weight of 14 lbs. at the end of a lever of 2 ft. This is equivalent to a torque of 176 lb. ft., and is equal to a pull of 112 lbs. on the periphery of a pulley of the same diameter as the armature, viz., 6 in. At the same time the motor could momentarily exert a maximum torque of about five times that amount without damage.

At the *Thibaut shaft of the Société Anonyme de Saint Etienne*[11] an electric winding engine was in 1883 at work, drawing from 20 to 28 tons in ten minutes up a 13 fathom shaft. A Gramme generator at the bank was driven with belt gearing of 20 to 1, by a small horizontal steam engine of 5 indicated H.P. The motor,

11. Oesterr. Zeit. für B. und H., 1883, p. 163-176. Trans. N. of Eng. Inst. M. E., vol. 33, p. 71.

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which was also a Gramme dynamo, was fixed at the bottom of the shaft, and geared to the winding drum at 250 to 1. Of the power indicated by the steam engine, 15 per cent. was absorbed by its own friction, and 50 per cent. was absorbed by the electric apparatus. The useful effect of the whole installation, which cost about £340, was 25 per cent.

In this case, neither the steam engine nor the electro motor seem to have been properly efficient specimens.

At the mines of *La Péronnière*, near Rive de Gier, *in the Loire Valley*,[12] extensive trials of electricity were carried out. A steam engine of 32 H.P. was used to drive a pair of Gramme dynamos, each of 8 H.P. The current was carried from them by cables of 16 No. 20 B.W.G. copper wires to a pair of similar machines placed in the workings and used as motors. The shaft is 437 yards deep, and the distance the current was carried, was in one case, 1312 yards (1200 metres) to a staple up which coals are drawn, and, in another case, 1650 yards to a gin bank. The motor was in one case attached to a drum which stands at the head of an incline 120 yards (110 metres) long with a gradient of 14½ inches per yard (4 centimetres per metre). The load raised was about 1760 lbs. (800 kilograms), and the ascent was made regularly in 1½ minutes. The work went on with great rapidity, starting and stopping being effected as gently as desired. It is stated that about 5·2 H.P. were used, and that the useful effect was 30 per cent. with 1280 revolutions per minute of the generator, but higher with a greater number of revolutions. During the whole of November, 1881, when this apparatus was under test in regular working, not a shift was lost or a tub stopped.

The experiments made at these mines included distances up to 3280 yards (3 kilometres), and proved that the useful effect obtained varied very little with the distance. Messrs Charousset and Bague, who have published the results of the working of this plant, have based upon their experience with it the following

12. Trans. N. of E. Inst. M. E., vol. 31, abs., p. 10; vol. 32, abs., p. 14; vol. 33, p. 83. Trans. Amer. Inst. M. E., vol. 10, p. 311. M. M. Charousset and Bague in Bull. Soc. de l'Indus. Min., ser. 2, tome 11, 1882, pp. 5-88.

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estimate of the cost of electrical winding plant to lift 1½ tons of coal from a depth of 22 fathoms in 151 seconds (2 minutes, 31 seconds) :—

Steam Engine, 20 horse power, - - - - -	£258
Bed Plate for Engine, 4 Plummer Blocks, 2 Plummer Bottoms, 5 Lubricators, Shaft for Friction Pulleys, Shaft to drive Gramme Machine, 5 Pulleys, Driving Belt, Contact Gear, Pins, Bolts, &c., - - - - -	150
Gramme Machine of 8 H.P. (generator) - -	140
Electric and Speed Meters, - - - - - -	13
Total at Bank, - - - - - -	£561
Gin complete, - - - - - - - -	312
Gramme Machine (motor), - - - - - -	140
Total, - - - - - - -	£1,013

To this must be added the cost of cables at 11d per yard in dry places, and 2s 2·33d per yard in wet places. Also the cost of erection both above and below ground.

At *Blanzy Mines*[13] experiments have been made with an electric gin for drawing coal to a bank at St. Chamond Pit. The gin was set up under a set of shear legs carrying a pulley over which a chain was passed—one end being wound on the gin or drum, and the other end carrying weights. These weights were varied from 13 to 30 cwts., and these were drawn up to the gin. The useful effect was obtained by comparing the work in weight raised with the power transmitted to the generating machine—a Gramme dynamo. The loss, therefore, includes that due to the friction of the gearing, &c., of the gin, the friction of friction-cones connecting the Gramme motor with the gin, that of the pulley on the shear legs, and that of the chain on the pulley and drum. The useful work done varied from 0·73 to 4·30 horse power.

The length of the conductors up to 700 yards, the extent of the trials, had no sensible effect on the useful work done.

The useful effect reached a maximum of 51½ per cent. when the Gramme machines were working to their full power.

13. M. Graillot in Bulletin de la Société de l'Industrie Minerale, ser. 2, tome 11, 1882 pp. 89-99. Trans. N. of Eng. Inst. M. E., vol. 31, abs., p. 13.

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III. HAULAGE.

At Zaukerode Pit.—In the autumn of 1882 the system of haulage by means of an electric locomotive was established in the fifth main crosscut of the Oppel Shaft of the Royal Colliery at Zaukerode, near Dresden, in Saxony.[14] This has been alluded to by Mr Arnold Lupton in the Transactions of the Midland Institute of Engineers, and more recently by Mr R. T. Moore in Vol. VI. of our own Transactions (p. 165). Both of these communications are accompanied by sketches, and Mr Moore gives, at Plate XII., of Vol. VI., an illustration of the locomotive, which has been lithographed from a photograph.

The level or road at Zaukerode is about 240 yards (220 metres) below the surface, and is about 790 yards (720 metres) long. It runs in a south-westerly direction from the first bottom in a straight line to the seam of coal, and receives the full tubs from the different workings, partly from a self-acting incline and partly from the fifth main level which is driven on the course of the seam. The length of line, clear of the sidings at each end for making up trains, is about 680 yards. In running, the south-eastern line is used by full trains, and the north-western one by empty ones, the switching always taking place to the right. As the locomotive is reversible, and has a seat with the controlling handles at each end, it does not require to be turned. The tubs are of about 15 cwts. gross weight, the load being in each 10 cwts. of coal. The total load of the trains is said by Mr Lupton to have been, when he saw them running, 13½ tons, or 18 tubs each, weighing when empty 5 cwts., and holding 10 cwts. coal. Mr R. T. Moore states the size of the race at 15 tubs and the total work at 25 runs, or 200 tons drawn per day. Mr B. R. Förster, however, states that in 1883 the total quantity drawn during the 16 working hours, between four a.m. and eight p.m., was 600 tubs, or 300 tons, and that this can be increased to 800 tubs, or 400 tons when in full work.

The details of line and wagons are as follows:—Gauge of line, 22 inches; steel rails, 2½ inch high, 2 ins. broad at the base, fish

14. Jahrbuch für das Berg. und Huttenwesen in Sachsen, 1883, p 39. Proc. Inst. C. E., vol. 78, p. 474. Trans. Midland Inst. of Eng., vol. 9, p. 296. Jour. Iron and Steel Inst., vol. 2, 1884, pp. 637, 638.

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jointed, and weighing 13·6 lbs. per yard. Wagons, 5 feet long, 2 feet 1 inch broad, 3 feet 3 ins. high. Capacity, 3½ cubic feet. Weight, empty, 550 lbs.; filled, 1,595 lbs. The locomotive is 8 feet long, 2 feet 7 ins. broad, 5 feet high, and weighs 3,520 lbs. The total length of 8 feet includes the space occupied by the driver's seat at each end, the body of the locomotive being 3 feet 2 ins. long.

On the surface is an inverted cylinder steam engine with 10 ins. diameter of cylinder and 8 ins. stroke. A belt from the fly-wheel drives the generating dynamo, the pulleys being about 3 to 1. The dynamo is a Siemens, No. Do size, running at about 660 revolutions per minute, the speed of the engine being 200. The current is led and returned by two naked conductors of copper wire as far as the shaft, which is nearly sixty yards distant from the dynamo. In the shaft well insulated cables are used for both working and returning currents, the main conductor being also armoured, and in the level or road the conductors are ⊥ shaped bars fixed along the roof and gripping the edges of the lower flange, are sliding contact pieces which are pulled along by the locomotive, and have insulated wires led from them to the electrical switch of the motor.

A variable resistance, consisting of a box containing bars of carbon immersed in water, is carried on the roof of the locomotive and is used to prevent the over-heating the coils of dynamo and motor by sudden variations of current passed through them. The amount of resistance thrown into circuit is gradually increased before stopping the locomotive, so that the dynamo is protected against the work being thrown off suddenly. This, however, is more or less of a complication and might be avoided by shunt winding the machines.

The useful tractive effect of the locomotive was determined by a Schäfer & Budenberg spring dynamometer, which was read at regular intervals during several trips, indicator diagrams being taken at the same time from the steam engine at the surface. The results have been given by Mr B. R. Förster in the following table, with the remark that the figures in the last column are not very exact owing to the difficulty of getting good diagrams from high speed engines. It is said that the practical results

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obtained show that trains of fifteen full or empty wagons can be drawn at speeds varying from 2·25 to 3 metres[15] per second (= 5 to 7 miles per hour) the distance of 620 metres (about 680 yards) being traversed in 3½ to 4½ minutes, the steam engine making 225 to 250 revolutions per minute.

No. of Observations.	No. of Wagons Drawn.	Tractive Power of Engine. A including. B without. 15 Kg. for its down traction.		Average Speed per Second.	Work done by Locomotive.				Steam Engine.		
		A	B		Condition A		Condition B.		Total Revolutions of Steam Engine during trip.	Revolutions per Minute.	Indicated H.P.
		Kg.	Kg.	Met.	Kgm.	H.P.	Kgm.	H.P.			
1	10 full, - - -	95	80	2·34	222·3	2·97	187·2	2·50	885	200·4	7·8
2	15 full, partly badly greased, - -	160	145	1·96	313·6	4·18	284·2	3·79	1038	195·9	13·8
3	20 full, well greased,	180	165	1·44	259·2	3·46	237·6	3·17	1242	173·2	14·7
4	20 full, some badly greased, - -	230	215	0·78	179·4	2·40	167·7	2·24	?	?	?
5	10 empty, - -	50	35	2·76	138·0	1·84	96·6	1·29	798	217·8	4·9
6	15 empty, - -	60	45	2·66	159·6	2·13	119·7	1·59	830	212·8	6·0
7	20 empty, - -	75	60	2·34	175·5	2·34	140·4	1·87	833	189·0	8·6

The highest duty recorded in these observations is that of No. 2, which is 4·18 H.P., but frequently the train of 15 loaded tubs is run at 3 metres velocity (7 miles per hour, *i.e.*, the speed noted by Mr Moore), and this duty then becomes 6·4 H.P. In arriving at the useful effect from No. 2 observation, 2·6 H.P. are deducted for the friction of the generator, this having been ascertained by a brake test of the steam engine. The amount of power consumed in friction of the spur gearing used in the locomotive between the motor and the wheels on the rails is taken at 25 per cent. of the work realised, and thus the effect realised by electric transmission is as 11·2 : 5·22 = 46·6 per cent.

The consumption of steam at 50 lbs. pressure per square inch was 8·101 cubic metres = 286 cubic feet for a loaded train,
and 4·200 ,, = 148·3 ,, ,, ,, light, ,,
or 12·301 ,, = 434·3 ,, ,, for the round trip.
In addition to this, there is a small loss of steam on account of

15. Metres into feet, multiply by ... ... 3·2809
Kilograms into lbs., multiply by ... ... 2·2046
Kilogrammetres into foot lbs., multiply by ... 7·233

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the steam engine being kept running when the locomotive is standing, unless when the stoppage is of some duration. The maximum due to this loss is, however, taken at 5 per cent. of the above quantity, so that the total consumption of steam per trip will not exceed 12·9 cubic metres, or 455·57 cubic feet, which, at the cost for steam at Zaukerode, amounts to little more than 6d.

At the establishment of this line, Messrs Siemens & Halske contracted to supply the necessary plant for an electric railway guaranteed to draw a gross load of 10 tubs or 7½ tons at a speed of 2 metres per second. The contract was for £700, and included one electric locomotive capable of travelling in either direction; one dynamo machine with steam engine; 700 metres of main (double) conductor, with insulators; 260 metres of cable for carrying the current from the dynamo to the workings; and sundry accessory and duplicate apparatus. The total cost of establishing the system was as follows:—

Contract as above, ...	£700	0	0
Freight to mine, ...	13	15	0
Steam pipes, bells, &c., ...	15	15	0
Signalling arrangements, ...	15	15	0
Extra conductors, &c., ...	18	13	0
Total cost of erection, ...	48	0	0
	£811	18	0

The erection was completed in September, 1882, by the staff of the colliery, without any special skilled assistants, an experienced fitter having first been sent for a week to the makers' works in order to become thoroughly familiar with the construction and working of electric machines.

The working cost for 660 waggons drawn per day of 16 hours is as follows:—

Driver's wages,...	£0	5	3			
Steam, ...	0	2	3			
Engine drivers at surface, ...	0	3	1½			
Lubrication, cleaning, and lighting,	0	1	1½			
				£0	11	9
Interest and depreciation at 15 per cent. per annum for 300 working days, = per day, ...				0	8	1½
				£0	19	10½

Or about ·77d per ton.

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With the full daily quantity of 800 wagons, it is estimated that this cost will be reduced about 10 per cent.[16]

As compared with horse or man traction, the proportional figures given are :—

	ELECTRIC.	HORSE.	MAN.
For 660 wagons daily,	... 3·01	... 3·71	... 6·2
„ 800 „	... 2·70	... 3·70	... 6·2

In the levels of the *Paulus and Hohenzollern Colliery*, near *Beuthen*, in Upper Silesia,[17] an electrical railway was introduced in 1884. It is said to be similar to the one at Zaukerode, but with more powerful machines.

The steam engine has one cylinder 24¾ inches dia. and 3 feet 8 inches stroke, the dynamo being driven by a belt from the fly-wheel.

The distance from the dynamo to the working level is 250 yards, and the total length of the line is 820 yards. The conductors of electricity are arranged as at Zaukerode.

The locomotive weighs 2 tons 2 cwts. ; the empty tubs weigh about 8¾ cwts., and they carry 10 cwts. of coal.

It is said that the cost of carriage by this electrical system has been found to be 0·191 pfennig per centner, or about ½d per ton, this being about one half cheaper than horse transport.

IV. VENTILATION.

At the *Mines of Blanzy* a stone drift was ventilated by a fan driven by an electro motor.[18] The shaft was 550 yards deep, and the drift 430 yards long, or 980 yards in all, and the air had to be carried this distance in pipes 11¾ inches diameter.

The drift was first aired by means of a waterfall, but this was proved to be insufficient, as the temperature at the fan was 95°.

16. Compare paper on Animal and Locomotive Power in Pennsylvania Mines, by A. W. Sheafer—Proc. of the Engineers' Club of Philadelphia, Aug., 1885; p, 150. Abs. in Min. Proc. Inst. C.E., Vol. 83, p. 524.

17. Zeit. für das Berg. Hütten. und Salinenwesen, vol. 32, p. 286. Zeit. für das B. H u. S. im Preussischen Staate, vol. 32, pp. 215-252. Jour. Iron and Steel Inst., vols. 2, 1884, p. 638; 2, 1885, p. 629.

18. Trans. N. of E. Inst. M. E., vol. 31, abs., p. 9.

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A fan was then put into the drift 150 yards in and driven by electricity, wires being led down the shaft from the dynamo for that purpose.

The fan was 2ft. 6in. diameter, by 11¾in. broad, and at 730 revolutions per minute delivered 13·42 cubic feet of air per minute at the face. The temperature was thus reduced to 89°.

When the Gramme dynamo at the bank was run at 1200 revolutions, the one in the mine used as a motor ran at 700 to 800, giving about 60% efficiency.

COMPARATIVE COST OF VENTILATING BY ELECTRICITY AND COMPRESSED AIR.

ELECTRICITY.

PORTABLE ENGINE, 10 H.P.		
2 Gramme Machines, ...	£120	0
Conducting Cable (Copper), ...	21	0
Return Cable (Iron), ...	3	15.64
Fixings for Cable in Shaft, ...	0	14.40
Frames to carry Motor and Fan, ...	2	1.88
Frames to carry Dynamo and Engine, ...	7	4.00
Erecting, ...	4	19.68
Shaft for Engine, ...	10	0.00
	£169	15.60

COMPRESSED AIR.

PORTABLE ENGINE, 10 H.P.		
Compressor (Sauter & Lemmonier), ...	£349	6.0
Pipes, ...	188	16.0
Elbow, &c., ...	0	14.4
Fixings in Shaft, ...	3	0.0
Bolts and Indiarubber Rings, ...	3	0.0
Erecting, ...	12	0.0
Masonry and Concrete, ...	6	0.0
Shaft for Engine and Compressor, ...	20	0.0
Sundries, ...	8	0.0
	£590	16.4

Zaukerode Pit.—For the separate ventilation of a lateral drift of the Zaukerode mine a 40 inch Schiele's fan is used, driven by a Siemens dynamo actuated by a Dolgorouki steam engine. The cost per 1000 cubic metres is 0·27d, which is said to be cheaper than compressed air machinery where special compressing plant for a small fan has to be put down.

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Trafalgar Collieries.—From the note supplied by Mr Frank Brain (see page 276) it appears that a 6 feet fan is being driven in the workings of this colliery at a distance of 1500 yards from the generator in the engine-house at the surface.

V. APPLICATIONS OF ELECTRICITY ILLUSTRATING GENERALLY THE TRANSMISSION OF POWER.

(*a*) *Marcel Deprez's Experiments* on transmission of power. Between Paris and Creil the length of line between the two stations is 56 kilometres (about 35 miles); and the return circuit being by wire, not earth, the total length of wire traversed by the electric current was 112 kilometres of a copper cable, equal to a single copper wire of 5 millimetres in diameter.

All the conditions of current, resistance, speed, and horse power were carefully measured and recorded, with the result that the generating dynamo running at 170 revolutions per minute developed an electromotive force of about 5700 volts, with 7 ampères of current, and a brake horse power of 61. The receiving machine or motor, running at 277 revolutions, received over 4400 volts, and developed a brake horse power of 40. There was no appreciable heating of the motor. The efficiency of the apparatus or the percentage of yield, both electrical and mechanical (or commercial), are, for two trials, as follows:—

Electrical yield.....	77 per cent.	78 per cent.
Mechanical yield.....	47·7 ,,	53·4 ,,

These are percentages of the electric force generated, but do not show the relation of the power received to that which was exerted in driving the generating dynamo.

This is, however, given in an exhaustive report to the French Academy of Sciences by M. Maurice Levy, as reporter of a Commission appointed to verify Mr Marcel Deprez's results.

M. Levy reports that the power consumed at Creil in driving the dynamo varied from 67 to 116 horse power, as the speed of the generator was varied from 168 to 218 revolutions per minute, and the electromotive force from 4887 to 6290 volts.

The power recovered at Paris varied from 27 to 52 horse power; the industrial yield having thus varied from about 41 to

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45 per cent. of the original power employed. The percentage recovered increased with the increase of horse power transmitted, the highest percentage (viz. 45) having been realised when 116 gross horse power were used, and 52 recovered at Paris. M. Levy remarks that "The fact that we can thus practically transmit 116 horse power to a distance of 56 kilometres, and derive an industrial yield of 45 per cent., accurately measured, not exceeding a velocity of 218 rotations of the generator, and this continuously, without straining the machines, is an extremely remarkable result which could not easily be expected, and which must be emphatically pointed out."

The analysis of results of M. Levy shows that the machine employed by M. Deprez produced electrical effects equivalent to those which would have required 200 Gramme machines using five times the power consumed in the Deprez Generator. The loss of power being the difference between 116 and 52 or 64 horse-power is thus apportioned :—

Loss in Generator,	32·2	H.-P., or	28 per cent.
,, Receiver,	19·1	,,	16 ,,
,, Line,	12·7	,,	11 ,,
	64·0		

And the principal loss which occurred as above in the generator is thus distributed :—

Mechanical losses (friction, vibration, &c.), ...	8·5	per cent.
Power spent in producing magnetic field, ...	11·0	,,
Heating of the ring (armature), ...	8·5	,,
	28·0	

M. Deprez had, previous to the Paris-Creil work, made trials[19] between Munich and Miesbach, and Vizille and Grenoble, transmitting through an ordinary telegraph wire, in one case half a horse power, a distance of 35½ miles, and in the other case 16 H.P. a distance of 32 miles. In the Munich-Miesbach trials Gramme machines were used for generator and motor. The total resistance of machines and line current (71 miles) was 1900 ohms, the wire being of galvanised iron, 0·177 ins. (4·5 milli-

19. Comptes Rendus, tome 97, p. 628. Revue Universelle, &c., sev. 2, tomes 14, p. 51, 237; p. 257.

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metres) diameter, a return wire being used. With a velocity of 1500 revolutions of motor at Miesbach and of 2200 revolutions of generator at Munich, the efficiency of the system was 60 per cent. In the Vizille-Grenoble trials from 41 to 62 per cent. efficiency were realised.

(*b*) *Pumping at St. Elisabeth.*—The surplus power of the engine of a ventilating fan at St. Elisabeth[20] coal mines was used for generating electricity conveyed to a motor for pumping water at la Sorme for some boilers and farming purposes.

The distance between the engine and the pump was 775 metres (or about 850 yards), and from the pump to the farm and boilers 290 metres (or about 320 yards). The head against which the water was pumped was 20 metres (22 yards), and the quantity pumped 1½ litres per second, or about 20 gallons per minute.

(*c*) *The Cannon Foundry at Bourges*, in France,[21] has employed Gramme Dynamos for several years, as generator and motor in machinery for the testing of metals. There are also two 20-ton cranes for handling large ordnance, and these cranes are worked each by a special electro-motor supplied by current from a common dynamo. The power is transmitted about 130 yards, and about 13 H.P. are realised out of 25. The working has always been conducted without accident.

See also an account of an electric crane for foundry use at St. Ouen, in Jour. Iron and Steel Inst., Vol. II., 1885, page 616.

(*d*) An electric installation for working stamping machinery[22] at the *Phœnix Gold Mine* in Skipper's Creek, *New Zealand*, is interesting on account of the distance from the source of power to the Stamping Mill. Two large No. 8 Brush dynamo machines are used as generators, and a specially made "Victoria" motor is placed at the mill. The dynamo house is situated about two miles up the left branch of Skipper's Creek, where an open ground

20. Compt. Rend. Mens. Soc. de l'Indus. Min., 1883, pp. 239, 240. Trans. N. of E. Inst. M. E., vol. 33, abs., p. 82.

21. Compt. Rend. de l'Acad. des Scien., vol. 102, p. 97.

22. From the *Mechanical World* 24th Sept., 1886.

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race of half a mile in length gives a fall of water of 180 feet, the water passing down two wrought iron pipes 22 inches diameter, at the top and tapering to 6 inches at the bottom. The supply of water is equal to working 10 stamp heads, but at present (Sept., 1886), the electric apparatus is required to work only four or five heads. Two Pelton water wheels drive the dynamos. These wheels are 6 feet diameter, exceedingly simple in construction, and make 300 revolutions per minute, developing 50 H.P. when in full work, and having, it is claimed, an efficiency of 80 to 86 per cent. The dynamos are driven at 700 to 800 revolutions per minute by belting from a countershaft driven by belts from pulleys on the spindles of the two water wheels. Each dynamo is said to be capable of maintaining 40 arc lamps of 2000 candle power, with an electro-motive force of 2000 volts and a current of 10 ampères, which is equal to an output of 26 horse-power from each machine, or 52 from both. By means of a switch-board different combinations of the two machines can be made, but in general they are coupled in parallel to the main circuit. This consists of two wires (one outward and one return or earth wire) of No. 8 B.W.G., weighing each 433 lbs. per mile. They are carried upon poles as telegraph wires are carried, and the poles are also used to carry telephone wires connecting the Mill and the dynamo house.

The motor runs at 350 revolutions per minute, and by a belt from a pulley on its main spindle drives the cam shaft of the Stamp Mill. The stamp heads weigh 8 cwt. each on an average, and the motor drives 20 heads at the rate of 70 blows per minute, and is said to be quite sufficient to work 30 heads.

This is the first instance of the application of electricity to the transmission of power in New Zealand, and it is expected that it will stimulate such work there and be the means of utilizing natural sources of power although at some distance from places where that power is required.

VI. COMPARISON OF VARIOUS SYSTEMS OF TRANSMITTING POWER.

The writer purposed making a comparison as to cost and efficiency between electricity, steam, hydraulic power, compressed air, and wire rope transmission, but he found that so many

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engineers had already taken up this question that probably the most useful course he can pursue is to present extracts from some of the best of these comparisons.

Papers dealing very fully with the theoretical considerations involved in the various modes of transmitting power to a distance have been published by M. Arthur Achard, of Geneva, in Proc. Inst. Mech. Engineers for 1881, and by Prof. Reuleaux.[23]

The advantages of compressed air as a distributor of power have been fully ventilated recently in connection with a scheme for supplying Birmingham with power in this way. Recent numbers of the *Electrical Review* and the engineering papers have taken this up, and in *Journal of Gas Lighting, &c.*, 5th and 12th January, 1886, there are articles upon it. Similarly the American plan of distributing steam will be found described in Trans. Amer. Inst. M. Eng., vol. xii., p. 632. It is said that a project is on foot to carry out this system in Berlin.

The following articles may also be consulted:—On wire rope transmission for pumping, Jour. I. and S. I., ii., 1884, p. 622; the cost of haulage in Anthracite Collieries, Jour. I. and S. I., i., 1886, p. 282; transmission of power by steam, Jour. *ibid*, p. 283; and hydraulic pumping machinery, Proc. Inst. C. E., vol. lxxxiv., p. 513.

The papers by Prof. Schulz, A. Beringer, and Prof. John Perry, from which the following quotations are made, leave little to be added for the elements of a general comparison.

Prof. Schulz[24] draws a very minute comparison between the cost and applicability of electric force on the one hand, and that of power derived from steam, compressed air, or hydraulic power on the other, for boring and cutting machines, and underground hauling, pumping, and ventilating machines.

In the case of boring and cutting machines he takes the transmission of power to the face by electricity as about equal in cost to that of compressed air, and states that it may in some cases be rather cheaper; but when a plentiful supply and sufficient head of water are obtainable, hydraulic transmission is cheaper than either.

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23. Proc. Inst. C. E., vol. 84.

24. Zeitschrift des Vereines deutcher Ingenieure, 1884, pp. 149-179. Proc. Inst. C. E., vol. 78, p. 67. Trans. N. of E. Inst. M. E., vol. 34, p. 5.

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For distances of from 500 to 600 yards the useful effect of the electric transmission is about 50 per cent., against about 20 per cent. for that by compressed air, and to do the same amount of work the respective motive powers required are as 2 to 5. The electric system is proportionally the cheaper the greater the cost of fuel and the greater the distance to which the power must be transmitted.

Among underground locomotives the steam engine is the cheapest wherever it can be applied. The electric engine gives better results than those driven by compressed air; but the fireless locomotive invented by Moritz Honigmann, though not yet fairly tried, promises (according to Prof. Schulz) to give better results than either.

In the following table addition should be made for cost of extra ventilation to the results in the first two columns, as in these two cases two locomotives were at work.

UNDERGROUND HAULAGE BY LOCOMOTIVES.

	Steam Engines.			Compressed Air Engines.		Electric Engines.
	With Fire.		Without Fire			
	Doman Mine.	Cessous Mine.	Honigman's System.	Petan System.	Mekarski System.	Zaukerode Coal Mine.
Cost of plant in £, - - -	1600	1600	550	650	1000	800
Interest and depreciation per mile ton in pence, -	·42	0·14	·50	·79	·81	·44
Cost of haulage per do. in pence,	·60	0·51	·82	1·18	1·35	1·10
Total cost per do. in pence, -	1·02	0·65	1·32	1·97	2·16	1·54
Daily performance in mile tons,	303	882	88	66	99	146
Length of run in yards, - -	2530	5030	676	676	676	676
Time per run in minutes, -	2·3	3·3	1·5	1·5	1·5	2·6
Weight of machine in cwts., -	86·3	156·3	47·2	53·1	45·2	31·4
Height of machine, - - -	Ft. In. 6 3½	Ft. In. 6 10½	?	?	Ft. In. 5 1	Ft. In. 4 11
Breadth „ - - - -	4 3	5 3	?	?	3 7½	2 7½

When several Electric Locomotives are at work on the same line, the efficiency is considerably increased.

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Examples of Different Systems of Haulage.

	Rope and Tail Rope.	Rope and Counter Rope.	Endless Ropes. With Great Speed.	Endless Ropes. With Small Speed.		Endless Chain.		Electric Haulage for Comparison.
	St. Marie Pit, near Aniche.	Von der Heydt Pit, Saarbrücken.	Shire Oaks Pit in Nottinghamshire.	Bridge Pit in Nugai.	Meadow Pit near Wigan.	Barbach Drift, Saarbrücken.	Hasard Pit, Belgium.	Zaukerode Pit.
Cost of plant in £, - - -	1600	2300	1. 750	2. 2300	3. 750	4000	5600	800
Interest and depreciation per mile ton in pence, -	1·36	·255	·29	·37	·39	·78	·22	·445
Cost of haulage per do. in pence.	·52	1·01	1·80	3·65	2·00	·73	·22	1·09
Total cost per do. in pence. -	1·89	1·26	2·08	4·02	2·39	1·52	·44	1·54
Work done per shift in mile tons.	96	720	203	500	148	436	1983	146
Hauling distance in yards, -	600	4120	920	2170	640	1920	3500	676
Time per run in minutes, -	5·0	3·3	3·3	·6	·5	1·87	1·5	2·6
Duration of shift in hours, -	10	10	12	12	12	10	8	16

1. The full tubs are drawn up an incline of 1 in 48.
2. " " " 1 in 62.
3. " " " 1 in 21.

From the foregoing table it appears that the electric system compares favourably with most of the others as regards cost. The "rope and counter rope" haulage system and those by endless chains are better adapted for moving very heavy weights.

For subsidiary hauling engines, a comparison of cost between electricity and compressed air shows considerably in favour of the former; but hydraulic power in cases where it can be applied, is cheaper still unless the water has to be carried for very long distances.

Prof. Schulz publishes the following:—

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TABLE OF ELECTRICAL INSTALLATIONS.

NAME OF PIT.	Power of Motor.	Machine Driven.	Length of Lead.	EFFICIENCY.		
				Electrical.	Mechanical.	Total.
	H.P.		Metres.	Per Cent.	Per Cent.	Per Cent.
La Peronnière, near Rive-de-Gier, . . .	37·1	{ Hauling Machine }	1500	50·0	37·0	30
Thibaut, near St. Etienne,	5·0	...	250	45·0	38·0	25
Blanzy, ...	17·	...	634	...	51·0 ?	30
Zaukeroda, ...	14·7	Locomotive	893	46·6?	37·8 ?	30
Do.	5·0	Fan	780	50·0	26·0 ?	...
St. Claude, near Blanzy, .	8·10	...	900	...	...	...

In spite of his previous remarks, Professor Schulz concluded that there is no field for electrical transmission in mining (special cases excepted), except for hauling on levels by locomotives, which could advantageously replace rope or cable haulage. It is not clear how he deduces the figures in his last column. The "hauling machine" at Blanzy is probably meant for the winding installation mentioned *ante*.

A very exhaustive comparison between electrical transmission of force and other mechanical methods in use was published in Berlin [25] in 1883, and awarded a prize by the Electro-technical Society there. An excellent resumé of this paper, made by a French mining engineer, may be found in the *Revue Universelle des Mines, &c.*

The agents used for transmitting force which are here compared are—(1) Electricity; (2) Hydraulic pressure; (3) Compressed air; and (4) Tele-dynamic cables. The net cost of a unit of work in any given case is arrived at from the following elements:—

1st.—The cost of the power supplied by the prime mover;

25. Kritische Vergliehung der Electrischen Kraftubertragung mit den gebræuchlisten mechanischen Uebertragungssystemen, par A. Beringer; Berlin, J. Springer, 1883 Resumé by Ch. Arendt—Rev. Univ., ser. 2, tome 15, p. 522, &c.

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2nd.—The useful effect of the system of transmission; and

3rd.—The cost of the erection and maintenance of the system.

As a basis of cost of power from the prime mover the following figures, given by Professor Grove at Hanover in 1876, are quoted, viz.:—

For (1) Small steam engines,	fr. 0·400	or about	4d	per H.P. per hour.
(2) Moderate sized engines,	0·280	,,	2¾d	,,
(3) Large sized engines,	0·106	,,	1d	,,
(4) Hydraulic engines,	0·008	,,	·076d	,,
(5) Gas engines (gas at fr. 0·22 per cubic metre),	0·320	,,	3¼d	,,

In arriving at the cost of transmission per effective horse power by the various systems, only Nos. 3 and 4 of these prime motors are considered, and in all cases 14 per cent. are added to the cost of apparatus for interest and depreciation of plant.

I. ELECTRICAL TRANSMISSION.

The useful effect of this system is the product of the following partial effects:—

1.—The useful effect of the generator or dynamo machine;

2.—The useful effect of the conductor (wire or cable);

3.—The useful effect of the receiving machine or motor.

It is also necessary to distinguish in the total useful effect the *electrical* effect, which is given by the relation of the E.M.F. of the generator to that of motor, and the *mechanical* effect, or the relation of the effective work recovered to the total work supplied to the system.

The total resistance of the circuit must be known to obtain the electrical yield, and the author assumes 50 per cent. of the total resistance to be due to the generator and motor. This is much greater than has been found to exist in the experiments of Marcel Deprez and others. The resistance of the conductor is fixed by its section and material, this section being calculated in square centimetres for a given current by the formula $S = \frac{I}{\delta\delta}$, when copper is the metal supposed, and I = the intensity of the current in ampères. Suppose that we transmit successively 5, 10, 50, and 100 effective H.P., the yield of the system being

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50%, and the maximum tension used 1500 volts, with currents of 5, 10, 50, and 100 ampères, then we should obtain the following results :—

For intensities of	5	10	50	100	Ampères.
Section of copper conductor,	0·083	0·166	0·833	1·666	Cent².
Resistance in ohms per kilometre of conductor,	2·03	1·01	0·20	0·10	Ohms.
Loss of energy in kilogrammetres per second, according to $\frac{I^2 R}{9.81}$,	5·17	10·34	51·73	103·46	$= A_0$.

If K in kilometres be the length of transmission so that the total length with return wire is 2 K, this gives a loss of energy = 2 KA_0. According to the preceding suppositions, the loss due to the machines being the same, then the *electrical* yield of the system is—

$$E_u^1 = \frac{\frac{EI}{9·81} - 4\,KA_0}{\frac{EI}{9·81}} = 1 - \frac{4\,KA_0}{\frac{EI}{9·81}}$$

or

$$E_u^1 = 1 - 0·0027\,K.$$

To arrive at the *mechanical* yield we must take into account the loss of energy due to transformation. Supposing that 87 per cent. of the power furnished by the prime motor are transformed into electricity, and again 80·6 per cent. of this energy is transformed into mechanical power by the motor, then we must multiply the electric yield by 0·87 × 0·806 = 0·70 in order to obtain the definite mechanical yield—

$$E_u = E_u^1 \times 0·70 = (1 - 0·0027\,K)\,0·70,$$

and from these data we get the following results :—
For distances of—

Metres,	100	500	1,000	5,000	10,000	20,000
E_u =	0·69	0·68	0·66	0·60	0·51	0·32

These figures are, however, considerably under the results

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which have been obtained in practice, and may be taken as minimum results. This author estimates the cost of electrical installations as follows :—

For the transmission of 5 H.P.	to	100 metres,	total fr.	9342·50,	or about £374.
,,	10	,,		13,255,	,, £530.
,,	50	,,		50,750,	,, £2030.
,,	100	,,		81,950,	,, £3278.

II.—HYDRAULIC TRANSMISSION.

The elements whose useful effects have to be considered in this system are—

1st. A force pump, when a natural head of water is not available.

2nd. Pipes and accumulator.

3rd. Hydraulic motor, either turbine or water pressure engine.

The theoretical work necessary to raise a quantity of water Q to a height H is represented by $A = QH\delta$, when δ = weight of unit volume. If A_1 be the effective work necessary, the useful effect is—

$$E_u = \frac{A}{A_1} = \frac{QH\delta}{A_1}$$

or

$$E_u = \frac{Q\delta\ (H + h)}{A_1} \cdot \frac{H}{H + h}$$ when h = loss of water by friction expressed in height of water.

The first factor represents the useful effect of the pump, and the second that of the pipes. For well constructed pumps, a useful effect of 0·90 to 0·93 may be taken, for pumps of average construction 0·80 to 0·90, while rotary pumps have an estimated useful effect of 0·70.

Pipes.—The loss of force by water in traversing a long pipe = $h = \beta \frac{l}{d} \cdot \frac{v^2}{2g}$ where l = length of pipe, d = diameter of pipe, v = velocity of water. β = a co-efficient determined by experience.

The best diameter of pipe can be found by $d = 0{\cdot}816 \sqrt[7]{Q^2}$.

For average heads of water and diameter of pipes, the useful effect of pipes are for distances of—

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Metres,	100	500	1000	5000	10,000	20,000
$E_u^1 =$	0·997	0·985	0·970	0·85	0·70	0·40

The hydraulic motors which are usually employed are either turbines or water-pressure engines, giving a yield of from 60 to 75 per cent.

The product of these three partial useful effects gives the useful effect of the system.

III.—COMPRESSED AIR TRANSMISSION.

We have here—1st, Compressors;
2nd, Conducting pipes; and,
3rd, Air engine, analagous to a steam engine.

The useful effect of this system is extremely small where compression takes places according to adiabatic curves, so that, for a compression of 10 atmospheres, not more than 51 % would be realised, the remaining 49 % being absorbed in heat which is uselessly dissipated during the travel of the air. Isothermic compression, as carried out by Colladon at St. Gothard, should be used, as, by means of injecting cold water into his compressor cylinders, Colladon succeeded in compressing to 8 atmospheres without raising the temperature of the compressed air more than 25° C.

It is also necessary to use hot water in the air engine, so that the temperature there does not fall below 0° C., when ice forms in the cylinder. Under these circumstances, a useful effect of 80 per cent. for compressor may be obtained, and, in the air engine, a mean of 75 per cent. is found to be attainable for good permanent installations.

The loss in the pipes is small, being found to be 1·3 per cent. per kilometre. Multiplying the three percentages together, we obtain, for distances of—

Metres,	100	500	1000	5000	10,000	20.000
E u =	0·55	0·55	0·55	0·50	0·50	0·50

When drills are substituted for the air engine, the useful effect is very much less.

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IV. TRANSMISSION BY CABLES.

This is the simplest system, but is more easy to work at short distances. Supporting pulleys are used every 100 metres where the distance is great; or intermediate stations are established, in order to reduce the repairs, which are heavy when a single cable is used to transmit power to a great distance. The losses of work on this system are due to friction, resistance of the air, slipping of the cable on the pulleys, and the rigidity of the cable. These losses are found to amount to 4 per cent. per 100 metres, which gives a useful effect, $E_u = 0{\cdot}96$ per 100 metres. This agrees with Hirn's results, who found that, in transmitting 100 H.P. to 150 metres, a loss of 4 H.P. only took place. The losses become less for intermediate stations, so that 90 per cent. can be obtained for 1 kilometre. Experience also shows that, for lines of 1 kilometre and upwards, divided in stations of 100 [26] metres apart, the loss is 1 per cent. per 100 metres. An installation near Frankfort exists for transmitting 100 H.P. to 1000 metres in 8 divisions of 125 metres, and not more than 8 H.P. are lost, this making the useful effect—

$$E_u = \frac{100-8}{100} = 0{\cdot}92.$$

Similarly to the other cases, we obtain for distances of—

Metres,	100	500	1,000	5,000	10,000	20,000
E_u =	0·96	0·93	0·90	0·60	0·36	0·13

The following tables give the results founded on these figures of calculations of cost in francs per effective H.P. per hour of different amounts of power transmitted to various distances:—

---

26. 100 metres = 328 feet or 109 yards.
1000 ,, = 3280 ,, 1093 ,,
125 ,, = 410 ,, 136 ,,

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Table I.—Electrical Transmission.

Effective H.P. hours transmitted.	Distance of Transmission.						Kind of Prime Motor.
	100 Metres.	500 Metres.	1000 Metres.	5000 Metres.	10,000 Metres.	20,000 Metres.	
	Francs.	Francs.	Francs.	Francs.	Francs.	Francs.	
5	0·235	0·242	0·251	0·300	0·342	0·541	
10	0·209	0·216	0·221	0·264	0·322	0·504	Steam
50	0·195	0·201	0·207	0·237	0·284	0·441	Engine.
100	0·186	0·190	0·199	0·227	0·274	0·425	
5	0·036	0·037	0·039	0·046	0·054	0·087	
10	0·027	0·029	0·030	0·037	0·049	0·074	Hydraulic
50	0·024	0·025	0·027	0·030	0·032	0·057	Engine.
100	0·021	0·022	0·024	0·027	0·029	0·047	

Table II.—Hydraulic Transmission.

Effective H.P. hours transmitted.	Distance of Transmission.						Kind of Prime Motor.
	100 Metres.	500 Metres.	1000 Metres.	5000 Metres.	10,000 Metres.	20,000 Metres.	
	Fr.	Fr.	Fr.	Fr.	Fr.	Fr.	
5	0·261	0·295	0·329	0·680	1·091	2·066	
10	0·247	0·266	0·290	0·529	0·801	1·495	Steam
50	0·170	0·177	0·187	0·302	0·479	0·814	Engine.
100	0·169	0·176	0·185	0·299	0·431	0·712	
5	0·030	0·040	0·050	0·144	0·260	0·499	
10	0·026	0·031	0·039	0·099	0·172	0·330	Hydraulic
50	0·016	0·019	0·022	0·047	0·079	0·149	Engine.
100	0·016	0·018	0·020	0·045	0·075	0·119	

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Table III.—Compressed Air Transmission.

Effective H.P. hours transmitted.	Distance of Transmission.						Kind of Prime Motor.
	100 Metres.	500 Metres.	1000 Metres.	5000 Metres.	10,000 Metres.	20,000 Metres.	
	Fr.	Fr.	Fr.	Fr.	Fr.	Fr.	
5	0·281	0·308	0·343	0·603	0·992	1·745	Steam Engine.
10	0·265	0·280	0·298	0·466	0·651	1·079	
50	0·210	0·220	0·227	0·299	0·363	0·551	
100	0·209	0·212	0·217	0·272	0·322	0·469	
5	0·041	0·049	0·060	0·132	0·250	0·464	Hydraulic Engine.
10	0·036	0·040	0·046	0·091	0·148	0·413	
50	0·022	0·026	0·029	0·046	0·067	0·112	
100	0·022	0·024	0·025	0·037	0·052	0·086	

Table IV.—Transmission by Cables.

Effective H.P. hours transmitted.	Distance of Transmission.						Kind of Prime Motor.
	100 Metres.	500 Metres.	1000 Metres.	5000 Metres.	10,000 Metres.	20,000 Metres.	
	Fr.	Fr.	Fr.	Fr.	Fr.	Fr.	
5	0·117	0·152	0·196	0·569	1·085	2·374	Steam Engine.
10	0·116	0·144	0·177	0·469	0·886	1·991	
50	0·112	0·122	0·135	0·265	0·470	1·156	
100	0·024	0·119	0·127	0·230	0·399	1·016	
5	0·011	0·020	0·031	0·130	0·259	0·507	Hydraulic Engine.
10	0·010	0·017	0·026	0·100	0·199	0·416	
50	0·010	0·011	0·012	0·040	0·075	0·167	
100	0·009	0·010	0·011	0·029	0·052	0·124	

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The result of these comparisons is that assuming no special reasons for the adoption of any one of the systems in a given locality, electricity and cables are the best agents for distributing power. Of these two, cables give the cheapest transport up to one kilometre, and electricity beyond that distance.

It appears that hydraulic power transmitted by electricity to a distance of 20 kilometres[27] costs less than the same power produced on the spot by a large steam engine, so that the power obtained from water-falls can be economically carried some distance.

Over air and water electricity shows its advantage in cost at the longer distances. Up to one kilometre cable transmission costs less, but from one to five kilometres electricity takes the lead, and retains it before all the others, including even gas.

In his Cantor lectures on Hydraulic machinery, delivered before the Society of Arts in March, 1882, Prof. Perry gave an interesting and very complete comparison between the efficiency of the transmission of power by water and that of electrical transmission.

He said—"To take the general case of transmission of power by water, Darcy's experiments tell us that each pound of water loses $f\frac{L}{d}$ times its kinetic energy in flowing along a straight pipe of diameter d feet, length L feet, where f may be taken for a new 6-inch pipe = 0·0058. Or if Q cubic feet of water flow per second, and if P was the original pressure in pounds per square inch, then ·262 PQ is the horse power which enters the pipe, and ·0000665 $LQ^3 \div d^5$ is the power lost on the way. Thus, if E is the horse power entering the pipe, the power lost is ·00025 $\frac{LE^3}{d^5 P^3}$.

The following tables show the results with 6-inch and 3-inch pipes and different pressure :—

---

27. Francs into pence, ... multiply by 9·516
Metres into feet, ... ,, 3·2089
Kilometres (1000 metres) into miles, ... ,, 0·6214
Kilogrammetres into foot lbs., ... ,, 7·233
Cubic metres into cubic feet, ... ,, 35·316
Centimetres square into square inches, divide by 6·5

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PRESSURE, 700 LBS. PER SQUARE INCH AT ENTRANCE.

Horse-Power given in	Horse-Power lost in 1 mile.		Horse-Power lost in 10 miles.		Horse-Power lost in 100 miles.		Horse-Power lost in 1000 miles.
	6-Inch Pipe.	3-Inch Pipe.	6-Inch Pipe.	3-Inch Pipe.	6-Inch Pipe.	3-Inch Pipe.	6-Inch Pipe.
500	·125	4	1·23	40	12·5	400	125
1,000	1·0	32	10	320	100	...	...
2,000	8·	256	80	...	800	...	...
4,000	64·	2048	640	...	...	...	...
8,000	4096	...	5120	...	...	...	...
16,000	...	...	...	...	...	...	...
32,000	...	...	...	...	...	...	...

PRESSURE, 1400 LBS. PER SQUARE INCH AT ENTRANCE.

Horse-Power given in	Horse-Power lost in 1 mile.		Horse-Power lost in 10 miles.		Horse-Power lost in 100 miles.		Horse-Power lost in 1000 miles.
	6-Inch Pipe.	3-Inch Pipe.	6-Inch Pipe.	3-Inch Pipe.	6-Inch Pipe.	3-Inch Pipe.	6-Inch Pipe.
500	·015	·5	·15	5	1·5	50	15
1,000	·125	4	1·25	40	12·5	400	125
2,000	1	32	10	320	100	...	1000
4,000	8	256	80	2560	800	...	...
8,000	64	2048	640	...	6400	...	...
16,000	512	...	5120	...	...	...	...
32,000	4096	...	...	...	...	...	...

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PRESSURE, 70 LBS. PER SQUARE INCH.

Horse-Power given in	Horse-Power lost in 1 mile.		Horse-Power lost in 10 miles.	
	6-Inch Pipe.	3-Inch Pipe.	6-Inch Pipe.	3-Inch Pipe.
500	15·6	...	156	...
1,000	125	...	...	...
2,000	1000	...	...	...
4,000	...	...	...	...

With reference to electrical transmission, Prof. Perry said: "The law I have given you for the transmission of power by water is exactly the same as the law for electrical transmission:— The horse power put into a pipe at the place A : the horse power taken out of the pipe at the distant place B : : the pressure at A : the difference of pressure at A and B. So the horse power going into a wire at A : the horse power taken out of a wire at distant place B : : electric potential at A : the difference of potentials at A and B.

If P is the electro-motive force or difference of potential in volts produced by a generator of electricity (this corresponds with pressure in water), E is the horse power given by generator to wire.

Horse power wasted in transmission $= \frac{E^2}{P^2} 746 R$.

Now, for copper wire 1 inch in diameter, the resistance (R) of one mile is 0·058 ohms. Therefore, if l is distance in miles and d the diameter of the wire in inches:—

$$\text{Wasted horse power} = \frac{E^2}{P^2} 746 \times \frac{0{\cdot}058\, l}{d^2} = 43{\cdot}2 \frac{E^2 l}{d^2 P^2}$$

The following tables give an idea of the loss in transmission of power:—

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POTENTIAL 80,000 VOLTS.

Horse-Power given in	Horse-Power lost in 1 mile.		Horse-Power lost in 10 miles.		Horse-Power lost in 100 miles		Horse-Power lost in 1000 miles.	
	½-Inch Wire.	¼-Inch Wire.	½-Inch Wire.	¼-Inch Wire.	½-Inch Wire.	¼-Inch Wire.	½-Inch Wire.	¼-Inch Wire.
500	·007	·027	·07	·27	·7	2·7	7·0	27
1,000	·027	·108	·27	1·08	2·7	10·8	27·0	108
2,000	·108	·432	1·08	4·32	10·8	43·2	108·0	432
4,000	·432	1·728	4·32	17·28	43·2	172·8	432·0	1728
8,000	1·728	6·912	17·28	69·12	172·8	691·2	1728·0	6912
16,000	6·912	27·648	69·12	276·48	691·2	2764·8	6912·0	...
32,000	27·648	110·592	276·48	1105·59	2764·8	11055·9	...	...

POTENTIAL, 8000 VOLTS.

Horse-Power given in	Horse-Power lost 1 mile.		Horse-Power lost in 10 miles.		Horse-Power lost in 100 miles.		Horse-Power lost in 1000 miles.	
	½-Inch Wire.	¼-Inch Wire.	½-Inch Wire.	¼-Inch Wire.	½-Inch Wire.	¼-Inch Wire.	½-Inch Wire.	¼-Inch Wire.
500	0·7	2·7	7	27	70	270	...	...
1,000	2·7	10·8	27	108	270	...	...	...
2,000	10·8	43·2	108	432	1080	...	...	...
4,000	43·2	172·8	432	1728	...	...	...	...
8,000	172·8	691·2	1728	6912	...	...	...	...
16,000	691·2	2764·8	6912	...	...	...	...	...
32,000	2764·8	11059·2	27648	...	...	...	...	...

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These comparisons as well as the data given in the preceding pages show that electrical methods have no cause to fear competition either as to cost or efficiency. The longer the distance and the greater the amount of power to be transmitted the more favourably does electrical transmission compare with other systems, but for this reason it has had a worse chance in early attempts than it would have had if its efficiency were greater on a small scale of distance and power.

The methods of working which are adopted in each case must of course suit the circumstances of the mine. The naked conductors of the Zaukerode pit would not suit a fiery locality, and they are not necessary. An electrical locomotive can be worked by means of storage batteries carried on the engine, and the danger of sparks from exposed conductors when short circuited can be thus abolished. For stationary motors the conductors can readily be so protected that nothing short of a fall of the roof would cut them, and the sparking at commutators is rendered quite harmless by surrounding the commutators with wire gauze, practically running them inside the case of a safety lamp. The sparks being at any rate very different from a continuous flame give much less opportunity for any ignition of gas even if unprotected.

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te M.F. J. Rowan's paper on
ECTRICITY TO MINING OPERATIONS."

Fig. 1.

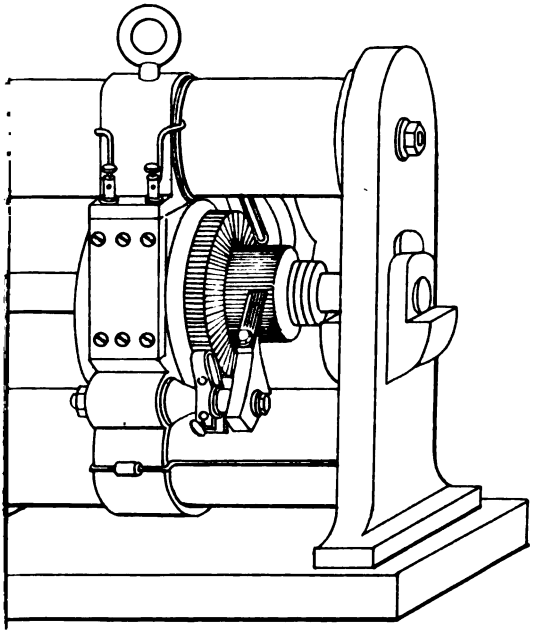

Fig. 2.

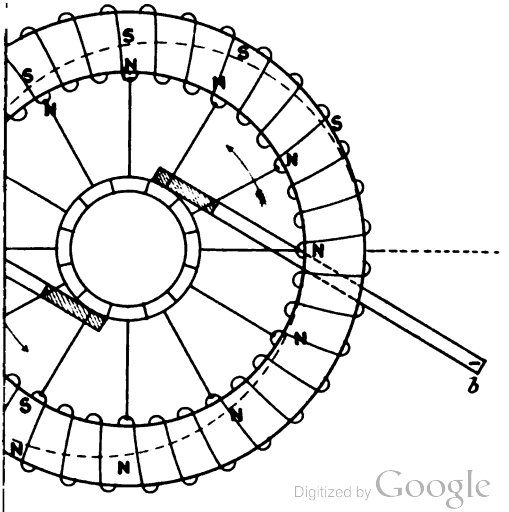

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Fig. 1.

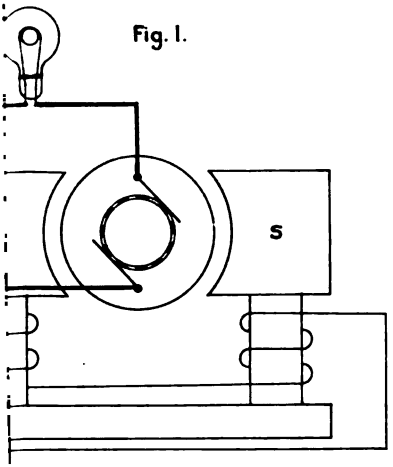


Fig. 2.

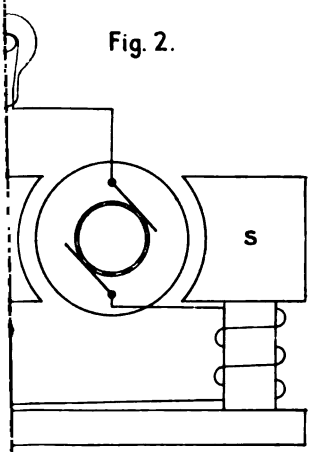
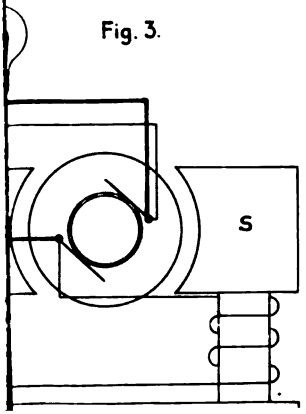


Fig. 3.



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te Mr. F. J. Rowan's paper on
LECTRICITY TO MINING OPERATIONS."

Fig. 1.

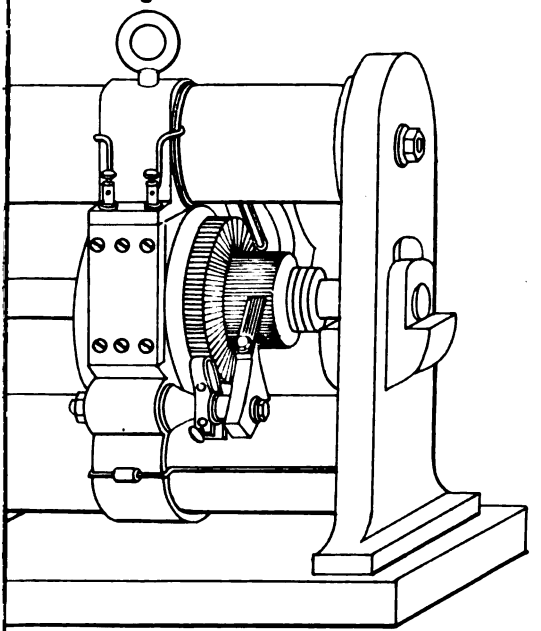
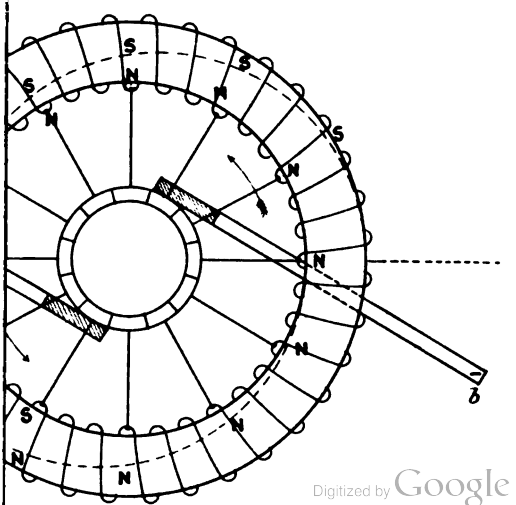


Fig. 2.



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THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE

ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW,

10th MARCH, 1887.

JAMES S. DIXON, Esq., President, in the Chair.

About 40 members were present.

The Minutes of the former Meeting were read by the Secretary and confirmed.

The following were elected by ballot as Ordinary Members :—

MARTIN WALTON BROWN, Coal Trade Offices, Newcastle.
THOMAS WOOD, Dalmeny.
WILLIAM FREW, Silvertonhill Colliery, Hamilton.
MATTHEW HECKELS, Heaton, Newcastle.
HUGH STRAIN, Bredinhill Colliery, Airdrie.
ROBERT WHITE, St. Lawrence Ropery, Newcastle.

The SECRETARY, on behalf of the Council, submitted a list of the members of Council who were eligible for re-election as office-bearers for the ensuing session; and thereafter office-bearers were nominated, in terms of Sec. V., Art. 3, of the Rules.

The following discussions then took place :—

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DISCUSSION OF THE COMMITTEE'S REPORT ON "THE COAL MINES REGULATION BILL."

THE PRESIDENT said, being in London last week along with Mr David Rankine, he received a remit from the Council of the Institute to represent the Institute on the occasion of the Conference of the Mining Association of Great Britain with the Home Secretary in connection with the New Mines Bill, and to state the views as embodied in the Committee's Report, subject to the restriction that it had not been formally adopted. Mr Rankine was engaged in the House of Commons that day as a witness, and could not attend the Conference. He did not find it necessary to say anything. The Home Secretary went over the Bill with the members of the deputation. He was glad to say, so far as he could gather, that the Bill had been very much modified, and whether they might flatter themselves that their action had some part in this he did not know, but he believed many of their suggestions had been adopted in the new Bill. After the interview, which lasted nearly three hours, he took the opportunity of having a private conversation with Mr Matthews, who was kind enough to say that he had got their report and carefully considered it. He also said if the Institute had any further information to send him he would be very glad to receive it as it was from such bodies he wanted information in constructing a really good Mines Bill.

The SECRETARY said he might mention, as illustrating the interest the Home Secretary had taken in the subject, that after a copy of their report was sent an order came to their publisher from the Home Secretary's Office for a dozen copies of the report.

The PRESIDENT said he fully explained to the Home Secretary the position of matters. He told him the report had been got up by a Committee of fifty or sixty gentlemen well qualified to consider such a question, and promised to forward any further discussion that might take place.

Mr HENRY AITKEN said—I regret exceedingly that, having been much abroad for some months, I was unable to attend the meetings of Committee.

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On the subject of Check Weighers, referred to by Mr Drinnan, I venture to say that if the present system of allowing the check weighers to take the weight of *all* material is to be continued, it will lead, as it has led in the past, to much bitter feeling and many delays of work, besides giving to the majority that undue interference with the minority which is not only wrong in principle, but contrary to that spirit of individual freedom which hitherto we as a nation have maintained; and I would much rather have the materials weighed for both parties by one man who would be a sworn weigher, and who would be bound to see justice done to both parties, not only as regards the weight of material "gotten," but who would be empowered to see that the material was in the state required by contract, and also have power to inflict what penalties or fines might be exigible for any breach of contract. He would also be sworn to secrecy. I advocate this now for the following among other reasons :—

1st.—It is the fairest.
2nd.—It would end the never-ending disputes which occur under the present system.
3rd.—It would prevent the interference of check weighers and stoppages of work.
4th.—It would give freedom to labour.
5th.—It is well known that, when there is a greedy pithead-man, the rate per ton is always higher than it should be, and that, although there may be an "outcome," it has been paid for by a larger rate per ton than if proper weight had been taken.
6th.—It would prevent the output of any man being known to all.

With regard to Mr R. T. Moore's observations, I frankly confess to being totally unable to see things in the light in which he desires us to view them. He vindicates a violation of the first principle of our law because the Mines Regulation Act has reduced the number of accidents. Admitting, for the sake of argument, that this is so, does Mr Moore contend that this violation of the principle of law constitutes the whole Mines Regulation Act, and that it is to this one point in the Mines Act

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we are indebted for the benefits he says have arisen? Surely this is begging the question, and is a species of special pleading not only clearly absurd, but quite unworthy of consideration. I have to add further that, when Mr Moore attributes to the working of the Mines Regulation Act the decrease in the number of accidents, he follows the lead of those short-sighted politicians who keep continually harping on the one subject, viz., that such and such a measure which was passed through the Legislature by those of his way of thinking has been the making of the British empire, forgetting all that has been accomplished by engineering arts, chemistry, science, etc. So, too, Mr Moore, forgetting the hundred and one improvements which have been made in getting and raising minerals, and overlooking the life killing anxiety of a generation of miners, would have us believe that all good results should be attributed to the adoption of the Mines Act, a contention which you will treat with the consideration it is worthy of.

Mr Moore goes on to contend that the employer only can enforce the law. How singularly inaccurate this is. The miners have the power under the Act of doing so, and the Government Inspector has the like power. Suppose even that Mr Moore is correct in this statement (which he is not), what possible connection can that have with the point in question, viz., making a man prove himself innocent of a criminal charge. The law is enforced by the employer, the employè, and the Government Inspector. Mr Moore's statement here is inconsistent with the facts in the next sentence. Mr Moore says a ship captain would be held responsible if he did not see that the look-out attended to his duty. Admitting Mr Moore is correct in his statement, he overshoots the mark. It is one thing for a captain on his bridge to see or hear a "look-out," but to compare such a situation with that of a manager of a mine, with any number of men out of sight or hearing, is absurd. Is a Government Inspector held responsible for the actions of his assistant? Is a General hung because a captain has turned traitor?

As to what Mr Moore says anent Mr Justice Wills's views: this gentleman was commenting on the law as it is; we are now discussing what the law should be—two very different things.

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Mr Moore says that the doing away with this most unjust part of the law would practically repeal the whole Act. I venture to say that this Institute never had made to it a more ridiculous statement, and one less worthy to be considered. Mr Moore says, if you judge colliery managers on the same lines as you judge all other breakers of law, you will practically repeal the whole Act. Nothing more need be said on this point.

Mr Moore goes on to say that this rule will be no great hardship, as all who go into the trade know what responsibility they are undertaking. What can Mr Moore mean by such an observation? We are here discussing how to make good laws and free every class from hardship. When we have lost every sense of independence and all energy to fight against *a wrong*, it will be time to sit down and accept Mr Moore's "no great hardship."

Mr Moore says that in all matters the majority govern the minority. Does Mr Moore mean by this that the minority shall be bound to pay a part of the check weigher's wages, or that the minority cannot say that they desire that the check weighman shall not see their weights, or what does he mean? I can see no connection between the point at issue, and the paying of taxes by a minority.

As to the position of fans, why does not Mr Moore say where fans should be placed so that "it would not be injured by an explosion." Let him tell us this and, if the committee approve, let his recommendations be embodied in their alterations. I will gladly add my views.

As to when the use of safety lamps should be made compulsory, when I opened the discussion on this subject I pointed out that in my opinion the proper course was to refer the point to a court consisting of owner, manager, inspector of mines, miners (working in the colliery) and a mining engineer, and this court would determine when and in what parts of the mine (or the whole) safety lamps should be used.

Mr Moore advocates putting up props every six feet from tree to tree no matter whether in a mine four feet or eleven feet wide irrespective of the condition of the roof. I will not take up the time of such an Institute as this by discussing such a point. Mr

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Moore adds quite sufficient to shew the absurdity of such a rule. I go further and I say that such a rule would, or rather might, lead to carelessness, because if a manager or oversman saw the trees up every six feet he would be less likely to see that they were put where wanted.

I recommended when I opened the discussion on this subject that every member should vote on each alteration proposed by the committee. Had this been done we would have had the finding of the majority—which is the god of law in this generation—the "perfect way."

The PRESIDENT said he had a note from Mr J. R. Williamson, calling attention to a slip in the Committee's report, p. 208, by the use of the word "reversion" for "reversal." He (the President) might call attention to a further slip in his remarks, p. 267, of the word "tightly" for "lightly," which gave a different meaning to the sentence.

Mr AUSTINE said he noticed a discussion on p.p. 266-267 in regard to the position of fans for being safe. Without discussing the matter in any way, he wanted to tell the meeting what took place during a series of explosions at Cadzow Colliery ten years ago. The explosions took place in the up-cast shaft, and they occurred at intervals of from 12 to 17 minutes, from eleven in the forenoon till twenty minutes past three in the afternoon. Generally speaking no damage was done at the pit mouth, because the pit was open—the pit-head frame was up, but there were no fittings round the mouth. There was one particular explosion more severe than any of the others, which occurred, he thought, about half-past twelve. Not only was it severe as regards the loudness of the report, but the concussion ran along the fan drift, blew part of the roof off the fan house, and extended the walls considerably. They were to recollect that there was no covering on the shaft; it was quite open. The fire was seen many yards above the pit-head, and notwithstanding that the shaft was open, the concussion, as he had said, ran along the drift to the fan, which was forty-five yards from the pit-head, and knocked the roof off it.

The SECRETARY asked at what angle the fan drift leaves the shaft.

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Mr AUSTINE said the fan is at right angles to the fan drift where it leaves the shaft. The drift went off at the side of the shaft and curved round gently to the fan.

The SECRETARY—Is it level?

Mr AUSTINE—It is practically level and ten feet in diameter.

Mr RALPH MOORE said it was a very curious fact that Mr Austine had mentioned, and showed that there really was no rule. He thought they could not go wrong in saying there should be no fans over the pit. He could not say where and how far safety would be after this very notorious case, and he thought the President had had an experience in connection with his own pits which showed there was no hard and fast line. He was not so fortunate as to hear the whole of Mr Aitken's remarks, and he just heard what he said about the distance apart of props. They were to bear in mind that he was not speaking on behalf of the framers of the Bill—he was merely giving his opinion as a member of the Institute. Mr Aitken said if props were put four feet apart very likely the miners would not pay attention to them, and would not put them in their proper place. He might not be aware that for several years the Coltness Iron Coy. had had a rule that all props were to be put not more than six feet apart, and it had produced fewer falls of roof than they had before. He thought also that the Clippens Oil Coy. had a rule that they were to be not more than four feet apart, whether the roof required it or not, and the effect was that there were few falls. He knew, moreover, that in Staffordshire, where the falls had been much more numerous than in any part of the kingdom, owing to the attention to propping they now showed very respectably indeed. He did not think there was any danger of what Mr Aitken contemplated occurring. The same with sprags. In the Clyde Coal Co.'s rules they were to be every six feet.

THE PRESIDENT—The committee recommend that.

Mr RALPH MOORE said, according to Mr Aitken's argument, the same rule would apply to sprags, viz., that they might be put up where not required. Well, while he would certainly hold, as he had always held, that it would be better, he did not know but it would be more economical, to have a set of men set apart to set up the props. He did not see why they should not.

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They used to have colliers brushing the roads as well as bringing down the coal. Now they found it advantageous to have a different set to do the brushing. He thought the same thing would follow the employment of special men to set up props, if they had the courage to go into it. He recollected five and twenty years ago having an arbitration with a party who said it was not necessary to examine the places before the men entered, and the arbiter said it was not necessary. Nobody would think of doing that now. It just showed the progress of events. While he was on his feet, he might state that when in London last week he found the committee's report had been forwarded to the Home Office. Now, there were two points he found fault with. In the first place, the Mining Institute of Scotland was large enough in itself and of sufficient importance to send any inquiries it had to make to the Home Office, and its Secretary was important enough to send them. They should have sent them through the Secretary or President. He did not see the reason why they should be obliged to get Mr Jamieson or any other person. In the next place, he thought it was premature to send the report at all. He did not see why the Mining Institute should have sent a report which was under discussion.

The SECRETARY said he was instructed by the Council to send copies of the report to the Home Secretary, and in asking Mr James Auldjo Jamieson, who is Crown Agent, and also a member of the Institute, to forward them, he specially mentioned that the report was still under discussion and had not been formally passed by the members, but from the fact that it had been stated by the Home Secretary that he would be glad to receive information from any quarter, and it appeared the Bill was to be introduced soon, the Council thought it proper that the committee's report should be forwarded as soon as possible, but with that explanation.

The PRESIDENT said the Council in discussing this matter had before them that the Home Secretary had asked for all information, and they thought that to wait till the discussion was completed might be too late. By reading the report, however, the Home Secretary would see in the last sentence that the

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discussion was going on, and, as Mr Barrowman had said, that explanation was given.

Mr JOHN DURIE said he thought it the duty of coalmasters and managers in every part of the country to strengthen the hands of the Institute in this matter. More especially he thought it the interest and duty of those connected with mining in non-fiery mines to strengthen the hands of the committee as regarded that part of the report which refers to these mines and the proposal of Government, so far as appeared, to put them on nearly the same footing as fiery mines. The only point in which he differed from the committee was in reference to the check-weigher. He thought it would be far better to adhere to the regulation presently in force in the old rules than to take up the complicated regulation the committee had made. He thought it far better that he should be appointed from the ranks of the workmen than that an outsider should be brought in. He might be a very disagreeable person, and might in many ways do injury, and he did not see any hardship in confining the selection to the workmen. He might say, in regard to the committee's contention, that the enactment of the 1872 Act with reference to holding the manager or the owner guilty of an offence till he proved himself innocent, he was quite at one with the Institute in trying to get that amended, although he thought it would be difficult to get it changed. He differed from Mr Robert T. Moore most distinctly when he held that it was not an infringement of a fundamental law. He thought it was not only an infringement of a fundamental law, but of the fundamental right of every man by which he was held to be innocent until proved to be guilty. In reference to the proposed condition as to the examination of mines, he came from a non-fiery district. They had no experience of fire; he never saw it in any of their pits, and it was more as one from a district of that kind that he spoke. He found that the first grievance they would have to complain of was in regard to Rule 2. That was in reference to the Dumb Drift. He could not see that there was any necessity for mixing the air in feeding the furnace in a pit where inflammable gas was never seen in the memory of man. He, however, thought that a far more objectionable proposition

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was made in Clause 4, in reference to the inspection of all places, whether the pit contained inflammable gas or not, by means of a locked safety lamp. There was no doubt, as it had been contended, that an inspection with an open lamp was more secure than with a locked safety lamp. He thought no one would gainsay that; but he thought there was a more serious objection to the rule, because any miner going into a non-fiery pit with a locked safety lamp to examine for gas must consider his occupation very much of a farce. He was looking for inflammable gas where no one had ever seen it and never would see it; and, if that part of his duty was very much of a farce, he would be inclined to place the other part in the same category, and would not properly examine the sides and the roof, which it was most important that he should examine. Referring to the clause providing for the setting of props at stated distances, the speaker said he objected to this as unnecessary. It was not the practice in the Lothians, and he was not aware of any district that was so free from accidents from falls as the Eastern district. In the colliery with which he was connected, he did not recollect a single miner being even injured, far less killed, from this cause, and if props were set where not needed it was more than likely that they would not be set where it was absolutely necessary that they should be set. In his colliery, very often in distances of 20 and 30 yards the roof was as safe as the roof of that hall. It would be an absolute waste of money to put up props there, and, as he had said, if they wasted money in securing safety where it was not necessary, they were apt to take away the provision against accident where it was most necessary provision should be made. He came there for the purpose, as far as lay in his limited power, of strengthening the action of the Institute. He trusted that they would state with emphasis their objections to the Bill. There was no Association could speak with greater authority. He was sure any recommendations which they made would receive from the Home Secretary that attention due to them, and as a result of their representations some modifications would be made which, while securing the safety of the men to the utmost possible limit, would do away with any provision which would unduly hamper managers of mines and unduly add to the cost of produc-

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tion. It took them all their time to compete in the markets of the world as it was, and if ridiculous restrictions were imposed, instead of a benefit, the result would be a blow struck at the future success of the hitherto very prosperous mining industry of the country.

Mr HENRY AITKEN, replying to Mr Ralph Moore, said a sprag and a prop were two very different things. They put in a sprag to a thing they expected to fall, and put it in to prevent it from falling, because they knew it would fall sooner or later, and also to carry forward the weight and break the coal off at the back. He had seen where it was advisable to put them in every 4 feet, far less every 6 feet. But sprags in working faces and props in roads and workings were not in the same category.

Mr RALPH MOORE said Mr Aitken had mistaken him entirely. He did not say sprags and props were the same thing; at least, he did not intend to do so. He merely gave it as an instance where sprags were sometimes asked to be put in every 6 ft. He had got that inserted into some special rules, but was often met with the remark that there was no use putting in sprags, the coals were too hard to come down. He was, however, certain, in the rules in which it was made compulsory to put up sprags, it had been a benefit.

Mr ALEX. ROXBURGH, as a master from the East, said he had nothing to add to what Mr Durie had said so well. He thought, it would be a farce for a man to go about with a safety lamp looking for a thing that was not there. He might go about for a generation and not find gas. He would consider he was just playing himself, and if he came to regard one part of his work as frivolous he would be apt to regard it all as such. Then, could it be said to be for the safety of the men that the fireman should be going about with a thing he could scarcely see with looking for a defective roof? It was preposterous, and he hoped the Institute would support the colliery owners in the East in seeking to have this remedied. It was simply trifling with legislation in asking that such a clause should be inserted into such a Bill. He thought a strong representation ought to be made. He understood the Bill was expected to be read a second time soon. It was not printed yet, and, consequently, was not in the hands of members.

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He saw a paragraph in the *Scotsman* that it was not in print because the Home Secretary was giving effect to representations of the Mining Association. If the second reading was coming on so early as that, they would require to take action immediately after the Bill was issued. He thought to wait till next meeting of the Institute would be a mistake, and he would suggest that the Secretary be instructed to call the Committee together as soon as the Bill was printed, and that a meeting of the Institute be afterwards summoned. They had been dealing with a Bill brought in by Mr Childers, and did not know how far the new Bill might agree with it. They had been working as it were in the dark, but they would now know what was proposed. They should not put off any time; if any representations were to be made they should be made at once.

Mr RALPH MOORE said of course they could not expect him to say anything further than this: His colleague and himself took great care that all the representations in the report were fairly discussed and fairly considered. They had to make the statement that the report was still under discussion, and that they thought it was premature to send it as the opinion of the Institute, which it was not. But all the matters were carefully considered. He quite agreed, as he had all along said to the Institute that now was the time to make any representation that was wanted. They should lose no time. The Home Secretary was glad to get any points discussed; above all things, if they were to have a Bill, let them make it as right as possible.

Mr JAMES GILCHRIST said although he was the manager of what was called a fiery mine, he had considerable sympathy with those engaged in non-fiery mines; possibly this arose from the fact that he was brought up in a non-fiery district; and if the Rules 4 and 9 in Clause 45 of the Bill were made law, it would impose unnecessary restriction and extra expense on the owners of non-fiery mines, and be a great hindrance to the workmen who inspected the mines before work commenced in the morning.

In the discussion at last meeting Mr R. T. Moore says, near foot of p. 259—"The Committee seemed to think there were fewer accidents in mines examined with naked lights than in those examined with safety lamps. He did not know that facts

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would bear this out." Since that meeting he had examined the Inspectors of Mines' Report for 1885 of the Eastern District of Scotland and found that 38,490 persons were employed underground, and from the particulars given in that report had carefully estimated that 21,000 of these were employed in non-fiery mines and the remainder (17,490) in fiery mines. In the same year 75 persons were killed and 317 injured; but setting aside accidents that occurred on the surface, in shafts, and those caused by explosions of fire damp, there were 53 persons killed and 250 injured under ground. Of 303 accidents, of this number 148 happened in the fiery mines, or one accident for every 118 persons employed; while in the non-fiery mines 155 accidents occurred, or one for every 135 persons employed.

Mr RALPH MOORE asked if Mr Gilchrist had added the accidents from explosions.

Mr GILCHRIST—I deducted them.

Mr RALPH MOORE—Why?

Mr GILCHRIST—Of course, explosions cannot happen in non-fiery mines. In making a comparison, he thought it was only right to deduct the explosions.

Mr RALPH MOORE said he had occasion not long since to compare the accidents in six collieries worked exclusively with safety lamps in the Hamilton district and six collieries not so worked but working the same seams, and he did not find the results Mr Gilchrist gave, but it was just what he expected: there were fewer accidents in pits where safety lamps were used. While he was not giving any opinion on the question whether or not pits in which gas had not been found should be examined with a safety lamp, he had to say that he found that where safety lamps were employed there was better discipline. Indeed, there was one pit where 230 men were employed, and some years there was no accident at all; and if they looked to the collieries—there were not very many of them—about Hamilton where safety lamps exclusively were used, they would find that, not only in the matter of light, but in everything else, they were better managed.

Mr R. T. MOORE said if Mr Gilchrist had taken as his basis the number employed using safety lamps and the number using

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open lights, he would have arrived at a right comparison. There were many fiery collieries wrought with naked lights.

Mr ROXBURGH said he did not think they required statistics. They had common sense to guide them. He asked, would it lessen the number of accidents by falls of roof in non-fiery mines to inspect by means of safety lamps in the morning?

Mr RALPH MOORE said, like Mr Roxburgh, he declined to enter into the discussion of statistics. What he said was, in collieries where safety lamps exclusively were used there were fewer accidents than where they were not used. He said so most decidedly. He had tried it again and again. He said there was better discipline.

Mr JAMES SMART said Mr Robert Moore's remarks at our last meeting on the committee's report on this Mines Regulation Bill were something like the summing up of the Council for the promoters. Although a member of the committee, not one of the alterations meets his approval. He has no objections to make apart from the Bill, and no modifications of any of the clauses. No doubt the restrictions placed by this Act on such an industry as the coal trade are very vexatious. As to the first of these objections, that the owner, agent, and manager were each to be held guilty of an offence against this Act by the infringement of its clauses by any person whomsoever; Mr Moore considers that in this there is no great hardship, "as any one going into the coal trade knew the responsibility he was undertaking." If this Bill becomes law, we will certainly know that the directors of a company as owners, and every one in the management will have got a noose constantly about their neck which might be drawn by either a careless or vindictive workman, very tight, at any moment. The other day, seven gentlemen, directors of a lead mine near Rhyl, in Wales, were tried for manslaughter, a coroner's jury having returned such a verdict against them, because one of the workmen while going down a shaft (which he was strictly forbidden to do) fell to the bottom and was killed. There are many juries such as this Welsh one, and others also of opinion that capitalists should be held responsible for every accident that occurs. It is not conceivable that any Government would pass such an Act as would hold any person criminally guilty for an offence committed by another

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party. The exception taken to the amendment on the clause referring to the check weigher cannot have any connection with the safe working of the mine. The alterations are quite necessary, as for months back in Lanarkshire the check weighers at many collieries have taken complete control of the works, causing many idle days and considerable irritation amongst the men. All that is asked is that he be confined to the duty of checking the weight, which is surely not unreasonable. The rules 9 and 12 of this Act, as they stand, would perhaps be the greatest hardship in it, for where fire-damp has been found during three months (in however small a quantity) no open light can be used, and no shot can be fired until the workmen are removed from the mine. In very many of our Scotch mines fire-damp is only found at rare intervals, and in very small quantities, probably in some remote part of the workings, which render such precautions unnecessary, and which can only hinder the working and contribute to accidents from some other cause. What a hardship in our thin seams (and where gas may be found to the trifling extent indicated), it would be for a drawer to trail along a safety lamp all day! He could not possibly overtake the same amount of work. The withdrawal of the men when a shot was to be fired in a part of the mine where no fire-damp had ever been seen, or from the nature of the strata through which the mine has been driven none could possibly be found, would also be a very oppressive law, and tend to cripple our mining industry very considerably. The other amendments suggested by the committee are all necessary in the case of a large number of our Scotch collieries. As the character of the coal and the nature of the roof vary very much in different seams and districts, no hard and fast line of working can well be defined, as means which may be effective in one part may be quite useless in another, and it is certainly unfair to force a system of working that is not required upon any of our industries, which can only tend to cripple and impair their usefulness. In reference to Mr Ralph Moore's remarks as to the systematic propping adopted at Coltness, if his recollection served him, at one time there was an unusual number of accidents from falls of roof at Coltness. That would probably cause the management to institute some regular system. They would find that absolutely necessary; but

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what he complained of was, where there was a firm, hard, rock roof, they should be forced to do the same thing. He had no doubt, if any of them were in the same position as Coltness, they would see it to be to their advantage, but they did not wish to be forced into it. It was all very well for a place where it was actually required, but they should have some discretion allowed as to the space between the props. At many collieries where there was a bad roof, especially in the Splint coal, it was frequently necessary to have gears placed almost skin for skin, which was absolutely necessary, but such cases should be left to the management to decide.

Mr RALPH MOORE said he merely mentioned 6 or 4 ft. because Mr Aitken thought it would do harm instead of good. It was a very difficult problem to say where it should be so used and where it should not. As to the court suggested by Mr Aitken, he considered it would be a much more unmanageable thing than arbitration. But let them have something—the members had not suggested anything.

Mr JAMES HASTIE said he would like to say a word, as he had had a number of years' experience in all the different classes of roof. If a manager was to be responsible for so very much, he thought the question of where the trees should be set should be left to him, and him alone.

Mr RALPH MOORE said he was speaking more to the point as to when safety lamps should be used.

Mr DURIE—Mr Moore, he thought, stated it was in consequence of the greater discipline in fiery pits that there were fewer accidents from general causes in them than in non-fiery pits.

Mr RALPH MOORE—I said that in the same pits side by side where safety lamps were used alone, there were fewer accidents from other causes.

Mr DURIE—And you said this was in consequence of the better discipline in fiery pits?

Mr RALPH MOORE—Yes, I did say so.

Mr DURIE—Do you think it would add to the discipline of a non-fiery pit that a man should be going about with a safety lamp?

Mr RALPH MOORE—I would say probably it would add to the discipline.

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Mr SMART called Mr Moore's attention to what the committee said, viz., that safety lamps should be used in a mine in which inflammable gas existed to a dangerous extent.

Mr RALPH MOORE said that was the point. If a man was burned, they acknowledged they should have safety lamps, but others, though they had some gas, said no, there was no need for safety lamps.

Mr ROXBURGH said he had such confidence in the Inspectors that he would be perfectly willing to leave it in their hands.

Mr RALPH MOORE said they would do the worst thing possible to leave it in the hands of the Inspectors.

Mr ROXBURGH said he did not think any Inspector would insist on safety lamps where there was no fire-damp.

The PRESIDENT—The difficulty is where there is very little.

Mr ROXBURGH—I would have no objection to accept Mr Moore's decision in the matter.

Mr AITKEN said Mr Moore took exception to the Court he proposed to determine where and when safety lamps should be used. He came to the conclusion that the course he advocated was the only one which could be adopted, for this reason that no single arbiter would take the responsibility of saying when and where safety lamps should be used. They might hear any amount of evidence they pleased, make any number of examinations; if he decided that safety lamps were not to be used, something might happen shewing his decision should have been the other way, or they might order safety lamps to be used where not required, in order to avoid such a risk. They might have some men blown up, and the arbiter would curse the day he sat on that arbitration. This was the reason why he suggested a Court.

Mr RALPH MOORE said the responsibility would be only where they said there need not be safety lamps. He would be very glad if there were some simple test. If gas were found within three months, as in Mr Childers' Bill, then you must put on safety lamps. This was one test, but if it was thought too hard, suppose they said if gas were seen twice within six months, then for three months they should be obliged to use safety lamps. Everyone would understand such a rule as this. If they had

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some simple rule, it would be far better than to say where there was danger from gas, for that would be a matter of opinion.

The TREASURER, in reference to Mr Moore's proposal to make this a test question, said in an ironstone pit with which he was connected in Ayrshire, gas was only seen twice in ten years. Would they put gauze lamps on there? They fired one hundred shots every day.

Mr RALPH MOORE said he was not speaking of that, what he was saying was this, that an Institute like this were the proper persons to give an opinion on such a point as to where safety lamps should be used. For instance, in a case where gas was found but twice in ten years, no one would expect it after even three weeks had passed.

The TREASURER—It was seen on the Monday and again on the Tuesday morning.

Mr RALPH MOORE—Then I would say that that pit ought to have gone on safety lamps for some time.

The TREASURER—It never was seen afterwards, and there was a fireman going round every morning and giving in his report.

The PRESIDENT said he thought the Committee realized the difficulty, because it was discussed at great length, and this "dangerous extent" was the only kind of definition they thought of. He thought if Mr Moore's suggestion were carried out, viz., where found three times in three weeks it might meet the difficulty.

Mr GILCHRIST, as an illustration on this point, said they had once a man burned in Earnock. In the section where the accident had occurred they had wrought for nearly two years and had not found gas. The man was holing and heard something buzzing. He laid down his pick and hearkened for a few moments, and commenced to hole again, when the gas exploded and he was slightly burned, the cause apparently being that the gas had gathered round about him and in his clothes. They never saw it in that section again until they started stooping. There was no doubt, if it were once seen in a section, the fireman would take special precautions to look for it, and if seen, say four times within a month, they might then adopt safety lamps

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for three months, while, if not seen for that interval, then revert to open lights. It would of course put an owner to inconvenience and trouble to have to provide safety lamps and take precautions in the firing of shots, but if gas were seen so many times inside of a month, this would be quite justifiable.

The PRESIDENT said he was very glad to see some gentlemen there from non-fiery districts, because in the West of Scotland, the district with which most of them were immediately connected, they would never think of sending a man to examine a mine without a safety lamp. It would be a kind of a suicidal or fratricidal matter to do so. He, however, sympathised with those others in saying that where gas was never seen, it was quite unnecessary to employ safety lamps. He thought it was more than unnecessary; it did not give a man the same chance of inspecting the roof and the side as he would have with a naked light, and it would be equally applicable to metalliferous mines where safety lamps were not used. He did not agree with Mr Aitken's suggestion as to a proposed court. He did not believe in courts if they could avoid them. There was nothing like having everything hard and fast in an Act of Parliament so that there was nothing left to be decided by outside parties. It brought in an element of danger and disquiet that should be done away with if at all possible. In regard to the matter of props, there was one instance he would like to mention. In a colliery he visited lately in Fife, the seam worked was 14 or 15 feet high, and there was a strong roof composed of 4 or 5 feet of splint coal. To put up props there would be like putting up telegraph poles, and there would be more accidents from falls of poles than from falls of roof. He walked through hundreds of yards of roads, and there was not a prop to be seen. There was no occasion for props, because the coal roof never gave way. He thought Mr Roxburgh's proposition should be acted on, viz., the committee should be reappointed to report on the new Bill with full powers to send their criticisms to headquarters.

Mr THOS. D. WEIR said the Committee's recommendations would have more weight if approved of by the Institute. He moved that the Secretary be authorised to call a special meeting for this purpose, and this was agreed to.

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Mr AITKEN then moved that the Committee's report be approved of. He was unfortunately from home during nearly all the time in which the meetings of Committee were being held, but from what he had heard from time to time as to actings of the committee, he thought it would be impossible to get any body of men to be as unanimous as the members of Committee were on the proposed alterations. They had been practically unanimous, and in the conclusions they had arrived at they had been as fair and just as possible. They had ever before them the one point, viz., the conducting of the mines safely. The Committee had worked hard and produced good results. He coupled with his motion a vote of thanks to the Committee for what they had done.

Mr DURIE seconded. He thought the report was a very admirable one, and considering all difficulties they had come to a decision that should meet with the approval of all.

The motion was unanimously carried.

The PRESIDENT returned thanks. He said the Committee took a good deal of trouble, and he was very happy to think their labours had borne some fruit, as they had good reason to think they had. If further efforts in the same direction would tend to the same results he was sure the Committee would be most happy to do their best in the matter.

Mr R. T. MOORE complained that Mr Justice Wills's judgment, of which he had been at some trouble in obtaining a transcript, had not been included in the last number of the Transactions.

The SECRETARY said it was the opinion of the Council that it was unnecessary to print so much extraneous matter.

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DISCUSSION ON MR ROBERT BEITH'S PAPER ON "NOTES ON THE SINKING OF SHAFTS."

The SECRETARY read the following communication from Mr HENRY JOHNSTONE—The section of the strata sunk through in No. 3 Pit, Niddrie, given in p. 252, was measured *vertically*—not at right angles to the strata. The average inclination of the strata is about 55°, but near the outcrops it is considerably greater; hence the great apparent thickness of the "Stairhead" seam. Its real thickness, measured at right angles to the seam, is six feet. The section does not give the full thickness of the "Great" seam, as the shaft was sunk on its outcrop, and its centre line, along which the section was taken, only cut the lower portion of the seam. I have been asked by members of the Institute whether equally rapid progress might not have been made with the sinking with fewer men in the bottom, and whether the unusually large number employed by Messrs Beith Brothers, could be at all times properly and profitably placed. During the progress of the sinking, I had constant opportunities of observing this; and it is only fair to Mr Andrew Beith, who was in charge of the work, that I should state that his work was so arranged and carried out that I never once saw a man in the bottom unable to get at his work or working at a disadvantage. All the workmen, including enginemen, pitheadmen, and runners, were paid by the contractors; and although it became evident that the sinking would be completed some months within the specified time, no reduction was made in the number of sinkers employed, shewing that Messrs Beith Brothers were satisfied that their arrangements as to labour were the most profitable to them. As sinking through such highly-inclined strata is uncommon, it may be worthy of note that contrary to general expectation, the rise side of the shaft was found to give little trouble with loose stones, &c., and that the dip side was much more troublesome,—in some places necessitating wallings at short intervals. Reference has been made in the discussion to the use of concrete as a material for

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lining shafts. This was considered very fully before our sinking was commenced, but it was ultimately determined to adopt the ordinary brick lining. To wall a shaft sunk through strata yielding water, even in comparatively small quantity, so as effectually to tub the water off, would be a work of considerable practical difficulty, and would keep the sinkers much longer out of the pit bottom than is necessary for the brick walling. In the event of any portion of the walling giving way, after the shaft had been completed and fitted up, the difficulty of repairing or renewing it would be very much greater in the case of concrete than with brickwork.

Mr ROBERT BEITH, in reference to the number of sinkers employed in the bottom of the shaft, said in hard strata there were eighteen men engaged sinking, and in soft metals thirteen. Of course, they were aware that sinkers are not very steady, and with the view of always keeping the shifts full, the contractors had extra men to replace those who did not turn out. These extra men were the means of keeping the staff on the surface fully employed.

The PRESIDENT, in reference to Mr Johnstone's remarks about concrete, said he thought it was himself who mentioned that. It would not, he thought, be a difficult matter to provide against the drawbacks suggested by putting a hole in the concrete here and there. He thought one great advantage was that the sinkers could do the work. He was determined to try it when he had an opportunity.

Mr R. T. MOORE said he understood that in some of the English circular pits the practice was to face with brick and fill in with concrete.

Mr ROBERT BEITH said the bricklayers at Niddrie and South Wales took part in the sinking when no walling was going on.

The PRESIDENT, as there were no further remarks, said he had very great pleasure in proposing a very hearty vote of thanks to Mr Beith for bringing the subject before them. It was a very practical paper, and he was sure many members who had shafts to sink would turn up this paper and see how the various details were carried out. The mode of tipping the kettle and things of that sort they saw and forgot, but by reference to this paper they

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could get that at any time. The rate of progress at which these pits were sunk was something wonderful, and showed conclusively that a big shaft and plenty of men was the way to sink speedily.

The vote of thanks was heartily accorded.

DISCUSSION OF MR F. J. ROWAN'S PAPER ON "APPLICATIONS OF ELECTRICITY TO MINING OPERATIONS."

THE PRESIDENT, in introducing this subject, said he supposed they might look on electricity as the motive power of the future in pumping, hauling, and other mechanical operations below ground.

Mr ROWAN said that since last meeting he had become aware that Mr W. M. Mordey, the electrician of the Brush Coy., had made some experiments with incandescent lamps in an explosive atmosphere, and the results had just been published in the "Proceedings of the South Wales Institute" (Vol. xv., No. 2). On account of their importance he wished to refer to them, as they bore directly on the question of the safety of electrical apparatus in mines. Mr Mordey made some experiments with incandescent lamps to test the effect of breaking them in an explosive mixture of gases, and also further experiments to test the effects of breaking an electrical circuit under similar circumstances. He found that if the glass bulb of a 10-candle power lamp was broken in an explosive atmosphere, the filament not being broken, an explosion was caused; but where the blow

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was sufficient to break the filament as well as the glass globe no explosion was caused; and where he surrounded the glass globe with water and fracture of the lamp was produced, there was no explosion. If the blow did not break the filament the water did. It was proposed to surround the globe with carbonic acid, so that a similar result might be produced. The experiments made by breaking the electrical circuit in an explosive mixture had a more important bearing upon tne use of electrical machinery in mining operations. In these experiments it was found that the spark made at a switch or contact-breaker would not explode a mixture of gases, even when means were taken, by the introduction of a piece of carbon, to lengthen the spark artificially. Repeated trials gave the same result in this case; but when an electro-magnet was introduced into the circuit, in order to increase the tension and length of the spark, it was possible to fire the mixture. These experiments proved that the sparks from electrical switches or from the commutators of electric motors, unless very high tension currents were used, were practically harmless in mines. The lamps used by Mr Mordey were from ten to twenty times the power of those required for portable lamps, so that if the danger from the use of these was so small, in the case of miners' lamps, having a very small electro-motive force, the danger from explosions by sparks was practically nil.

The SECRETARY said, on the suggestion of Mr Rowan, he had sent the paper to some of the gentlemen to whom Mr Rowan was indebted for valuable information, and communications had been sent by three of these gentlemen, which, with the permission of the meeting, he would now read. The first was from

Mr RADCLIFFE WARD, who stated that concise information for colliery owners and others on this very important method of conveying and distributing power over their workings, is of undoubted value; and, so far as he was aware, Mr Rowan's very systematic paper is the first one dealing with the matter historically and up to date, naming the various installations so far carried out. As such, it is of interest and value from several points of view. The most interesting point of the paper to him was the reference to Captain Blanch Brain's pioneer work in the Forest of Dean, which at a comparatively early date in electric

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work it afforded him so much pleasure to assist in, rendered possible through the initiative and enterprising tendencies of the directors of the British Electric Light Company (Limited), the owners of the Gramme dynamo, and those who seconded that Board, their manufacturers and shareholders. It cannot be too often referred to, that at the date of the Trafalgar Colliery experiments with the tub of pig-iron, Captain Blanch Brain recognised and demonstrated the fallacy of the purely scientific (?) reasoning by which well-known men had laid it down as an infallible law that 50% was the maximum possible return from electric transmission. The admirable way in which that first pumping installation worked night and day, and the coolness of the motor during its continuous performance, shewed the thorough soundness of the facts elucidated and put into practice by Capt. Brain. He noticed on page 289 of the Transactions of the Institute (second paragraph), the reference made to M. Levy's criticism of the results of the Deprez experiments between Paris and Creil. He desired to state that M. Hippolyte Fontaine, for many years the Administrateur en Chef of the Gramme machine in France, where it has enjoyed an uninterrupted career of industrial prosperity, has pointed out that more economical results than those obtained by M. Deprez could be obtained by a certain grouping of modern Gramme machines. He mentions this not in disparagement of the energetic initiative of M. Marcel Deprez, but because the paragraph referred to seems to reflect injuriously on the capabilities of the Gramme machine. As regards compressed air, it is evident that apart from those instances in tunnel boring, &c., where it may be useful for ventilation, it cannot at all compete with electricity. A high pressure—and high pressures, if competition is tried at all, must be used—compressed air engine is a most difficult mechanical problem, and has baffled clever mechanicians for very many years, and is likely to do so for many more; on the other hand, a high pressure electric engine is a very simple machine. This difficulty is of course additional to the enormous frictional losses in transmission pipes. The tables given at the end of the paper instancing the superior economy of electric over hydraulic transmission, call to mind how a second-rate system may make, in good hands, more progress than

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a first-rate system in inferior hands. The case in mind provoking this observation, is that of the distribution of hydraulic power in London. Long before the Hydraulic Power Company in London had laid its high pressure water mains through the principal streets of the central portion of the metropolis, electrical people had been *talking* of the field that there was in combination with lighting stations for supplying power as the Hydraulic Power Company are now supplying it. But they only *talked* of it. He regretted to say that those men who by their perseverance and industry have done much to advance electricity in this country, lack up to the present (in this country) that strong determined capable financial and commercial backing which is necessary to carry through new schemes and new developments of industry. The state of electricity here, compared with the United States (excepting telegraphy) is a disgrace to the spirit of industrial enterprise of the country. Their brothers in the United States have, now they have once started, beaten those engaged here in heavy electric work all to pieces, mainly through the want of the financial element above referred to. The Hydraulic Power Company have, in London, whilst electric people have been helplessly *talking* of the field for work, &c., quietly gone to work and obtained Parliamentary powers, laid the mains, and are earning dividends. There is still, however, an immense field for the distribution of electricity in London for power purposes. No doubt colliery men, practical and energetic as they must be, will not long know the capabilities of electricity for hauling, coal getting, ventilating, &c., without utilizing it. In connection with a distribution of electricity for colliery working, no doubt the Lane-Fox system will be an important adjunct. This consists in attaching accumulators to the mains, so that there is a reserve of power, independently of the generators always on. The system is the subject of one of the earliest electrical patents of the period, and is a very valuable one, and is being largely used now, even on small installations. The utilization of natural gas from coal pits for the purpose of actuating electrical generators, is a very interesting subject, and combined with a proper system of collection of the gas, is no doubt one of great economical importance. He believed that Mr Arthur Shippey of

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London has a patent for this, utilizing natural gas with a system of collection. The carriage of coal over railways to the extent now existing, will no doubt be a thing of the past sooner than most people imagine; whether energy is produced at the pit by combustion of gas or coal. He thought that both colliery men and electrical engineers are under an obligation to Mr Rowan for his careful and useful compilation.

The second communication was from Mr ALBION T. SNELL, who wrote as follows:—Mr Rowan's paper deals with the question of electrical transmission in a very fair and impartial way, and will prove of great value to engineers, &c., who may be about to undertake cases of transmitting power. The collection of by far the best part of the data of the subject is very convenient, and I hope will associate his name with the subject. I have no time to go into a detailed criticism of the various methods of transmission, nor even to criticise the electrical cases quoted. But I may mention that we have mastered the problem of giving a motor constant speed with varying loads, no matter through what distance the power may be transmitted. We do this by means of two series-wound machines—*i.e.*, a series-wound dynamo and a series-wound motor. The theory is conveniently given in Kapps' work on the electrical transmission of energy. It consists in arranging the characteristics of the two machines so that the back E.M.F. of the motor shall be constant. This, of course, means constant speed on the recipient machine. The theory is simple—the skill lies in designing the machines with the required characteristic. I can do this within the limit of practical work. We have just finished two machines which satisfy these conditions. The motor is to give 10 brake H.P. at 1000 revolutions, and with 300 volts and 30 ampères. The line is about three miles long, and has a resistance of 1·5 ohms. The motor is to drive a stamping machine in a gold mine. The generator will be driven by water power. The dynamo weighs 17·25 cwts., and has a large factor of safety, since it will only give a duty of 16·5 H.P., and its maximum output is fully 25 H.P. The motor weighs 6·25 cwts., and is, I believe, the most powerful machine of its size and weight ever built. We have also designed a dynamo and motor to be used for driving a tram at a

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constant speed of 10 miles per hour. This arrangement, moreover, has the advantage that the car starts slowly and without jerks, for the dynamo ceases to excite as soon as the car is stopped. On the circuit being again made, the dynamo gradually excites and the motor then slowly acquires its maximum velocity; and, at the same time, should the resistance to motion be such as required more than the ordinary H.P., the current will increase, and double, treble, or even quadruple the torque of the motor from the moment of getting under weigh. A resistance to be inserted in the main circuit is also supplied for reducing speed in crowded thoroughfares, &c. This is only one case of the application. Messrs Immisch & Co. are also building motors of various descriptions for use on tram-cars with accumulators; and have tried all the usual methods of transmitting the power from the prime to the driven shaft, such as sun and planet gear, worm and wheel, chain gear, &c. On Saturday last, the Society of Mechanical Engineers paid us a visit and were shown various examples of the above quoted transmissions of energy. Amongst other things, a printing machine and blast fan were driven by Immisch motors. Also one of Mr Rowan's electrical rivetters was set to work on a bar of iron corresponding to a ship side for the nonce, and created no little astonishment by the rapidity and power of its blows.

The third communication was from Mr Sydney F. Walker, and was as follows:—

I beg to thank you for your kindness in forwarding to me a copy of your transactions, containing Mr Rowan's able paper on "Electric Transmission of Energy in Mines;" and also for the invitation through him to attend your meeting, or to send some remarks to be read at your meeting. I am sorry that business engagements here will prevent my attending your meeting, or it would have given me great pleasure to do so. In my unavoidable absence in the flesh, perhaps the following remarks may be interesting:—

Mr Rowan has dealt so fully with the matter, and has given so full an account of all that has been done up to the present, that he has not left much for anyone else to say.

Unfortunately, up to the present, very little indeed has been done in this country to make use of this transmission, Trafalgar

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Collieries being, so far as I know, the only instance. And not a great deal more appears to have been done in other countries. France has taken the lead in this matter, but even there, considering the extent of the country and the magnitude of her industries, the record is by no means encouraging; and Frenchmen have the reputation, rightly or wrongly, of being ever ready to adopt a new way of doing work, when the new plan has a scientific look about it, regardless of the fact that possibly the old plan might, though less scientific looking, have done the work better and cheaper.

Yet, notwithstanding all this, I do not think anyone who goes into the matter carefully can have the smallest doubt that transmission by means of electrical currents will supersede all other methods. Whether you consider its greater convenience, its first cost, or its working cost, you have one result all through, viz., that electric transmission is superior to all others upon all counts, except in rare instances.

Electrical engineers have been accustomed for some time past, when they are bewailing the dearth of orders for electric lighting, to comfort each other with the remark, that after all electric lighting is not much, only a sort of bye product, as some put it. Electric transmission is the thing—when it comes. But the question is—why is it so long coming? I think the causes are really not far to seek, and that electric transmission will follow by the same road that all other improvements have come, viz., by proving its adaptability. My particular experience in the past, perhaps qualifies me to become a sort of prophet in the future. I can well remember, when I was first trying to introduce electric signals into mines, being told by a Yorkshire colliery-owner to whom I introduced the subject, that he was not one of those who had more money than brains, and by another that he could do all with a mechanical signal that we could do with an electric. Yet I believe, at the present time, there are few collieries, except in Lancashire, where electric signals are not in use; and in the latter instance referred to, one of the largest pits in Yorkshire, the whole colliery is fitted up with them.

Another remark that was frequently made to me in the early days of signalling was—"Your signals are very good *when they work*

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right, but they are such a nuisance when they get out of order." We had exactly the same in the early days of telephone work, and of the electric light, and the reasons were two-fold. In the introduction of every new thing, especially into mines, you have to meet many difficulties that cannot easily be forseen; and you have always one ever-present drawback in the fact that those who use the apparatus at first have rarely much knowledge of its principles, so that when any little thing happens, involving perhaps two minutes' work to put right, the whole thing is laid off, because no one about the place can do what is required.

Apply these facts now to electric transmission and I think the cause of the delay in adopting it will no longer be a mystery.

With electric signals it is a nuisance to have them laid off, but it is only a nuisance; there are means always at hand of repairing them then and there. With electric light it is the same; but with electric transmission, I take it, the consequences of a failure might be very much more serious than with either of the others, so that colliery owners and managers have to look at the matter far more seriously than in the other cases, and to make quite certain of success before adopting electric transmission.

And unfortunately that is not the whole case against us. Among the ranks of so-called electrical engineers are men who know very little of the subject, but have taken it up in a restless, roving spirit, because it promises at the time higher gains and easier work. They have read a text book, perhaps fixed a bell and battery for themselves, and are forthwith ready to accept a contract to run the world by electricity. As a matter of course they fail, and then the blame falls—not on them—but on the unfortunate science they have misrepresented.

I do not, of course, include in this category men who, having been trained in one branch of engineering, gravitate into electrical engineering from a genuine love of the science, and who honestly set themselves to master its principles. Electrical engineering gains largely by the addition of such men.

A case of failure in transmission by electricity, I understand, occurred at the Marquis of Lothian's collieries, purely, in my opinion, through bad engineering. I understand that a 50 H.P.

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engine was placed at bank to drive an electric generator, the current from which was to drive an electric motor, which was to work a pump in bye. Notwithstanding the enormous power put in at bank, only a *very small* stream of water was pumped in bye. The electrical apparatus was replaced by a compressed air apparatus, the same engine being used, and it did its work well. Such a case, of course, gives the idea that electrical transmission is not economical; where really the fact was that whoever designed the apparatus did not understand his business.

There was a similar case of electric lighting at a mine in Yorkshire. A dynamo was placed on the surface, driven by the fan engine, cables led down the shaft, and the mine lighted with incandescent lamps, as well as the offices, &c., on the surface; only, unfortunately, the lamps could never be persuaded to burn more than a few hours—sometimes only a few minutes. This was another case of defective electrical engineering. The fan engine was condemned, delicate instruments were brought, and the system tested; and it was solemnly announced that there was no reason for the lamps behaving so: and eventually the apparatus was removed. I believe, in this case, a large portion of the trouble lay in the peculiar construction of the dynamo, and would not often be met with; but, if the man in charge had known his work, he would have thrashed out the cause, and the mere fact of its being a new thing would only have served to put him on his mettle.

And I am afraid that, after all this, there are other difficulties to be surmounted. One grave objection that is always raised to electrical transmission in mines is the possibility of firing gas by means of the spark at the commutator.

There are two or three replies to this. One is, that for most purposes your motor would rarely be placed where there was gas present. A second is, that you have to remember that, in order to fire gas, you must pass a spark *through the gas*. Anyone who has used an electric gas lighter will be familiar with this. Further, the spark passes from the brush to the commutator, with which it is in actual contact, and from the brush to the commutator segment, with which it was in actual contact right up to the moment of sparking; so that it is very difficult indeed for

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gas to be present in the exact position required for ignition. Further, I have myself tried to ignite gas delivered freely over the commutator of a dynamo running arc lights, and failed to do so. But there is an even more conclusive answer to the question, viz., we are wrong in supposing that a spark *per se* will ignite gas. Mr Mordey, in a paper recently read before the South Wales Institute of Engineers, has shown that it is quite possible to have a spark that will not ignite gas; and some experiments of my own show that Mr Mordey's results are correct, and that, moreover, the reason is, that you must have something over two volts electro-motive force in order to fire your gas. This being so, it is only necessary to construct your motors so that you shall never have more than two volts in the commutator spark, and the trick is done, as that is simply a question of figures. You have only to design your motor so that the E.M.F. between any two adjacent sections, including the E.M.F. due to self-induction, shall not exceed two volts. There are, of course, the possible sources of sparking, as when two cables break, and their ends come together, between which there may exist any tension you please; but this, again, is merely a question of careful work and a little forethought. Another, and, I think, a graver, difficulty in the way of the adoption of electric transmission, is the fact that at present the electro-motor stands alone. You have to convey the power given out by it to the work by means of gearing, belts, &c., and if it happens that the work done is reciprocating, as in a plunger pump, you have to interpose some form of converter, which again is a power waster.

In the steam pump, all you have to do is to bring your steam to the apparatus, and you have the full advantage of the steam doing its work direct. In some forms of underground hauling engines, and in windlasses for ships' use, you have the whole thing in a compact form, only needing steam or compressed air to be laid on. In the rock drills used in Cornwall, that are worked by compressed air, you have the same thing. It appears to me that, if we are to move on and be successful, we must have electric pumps, electric hauling engines, electric coal cutting machines, electric rock drills, &c., each of which can be placed down anywhere that a supply of electricity exists, and be set to

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work by merely fixing in place and connecting leading wires from the electric mains.

Nor do I see that there should be any difficulty in this, providing the requisite materials are forthcoming; and I am pleased to observe that Mr Rowan has himself made a very good start in this direction with his electric drilling machines and rivetters for ships' use.

It appears to me that what is required to solve these problems is, that a skilled mechanical engineer knowing something of electricity, and a skilled electrical engineer having a fair knowledge of mechanics, should unite their forces to work out each problem in succession; and I think that there cannot be the slightest doubt that, if properly supported by capital, they would reap an exceedingly rich reward from their labours.

I hardly think that either the electrical engineer or the mechanical engineer could do the work efficiently alone. Speaking for electrical engineering, my experience is that if I lived to the age of Methuselah, and employed very many more hours each day in its practice than we are physically capable of, the time would still be all too short to master all that one desires, and even to keep pace with what is passing is by no means easy work; and I imagine that mechanical engineering can pretty well occupy a man's lifetime as fully as electrical engineering, if he is to be master of it.

On either side, therefore, there will always be something wanting. The electrical man might puzzle for hours over some little matter that would be A B C to the mechanic; but united they should carry all before them.

With regard to Mr Immisch's motor, I can endorse all that Mr Rowan has said about it. It is, I believe, the outcome of years of patient study and experiment. The only fear that I should have with it would be that, the armature being rather complicated in construction, it could not easily be repaired by local firms, and it might be a serious matter if it had to go to London every time. Such a condition as that would undoubtedly delay the adoption of electric transmission.

With regard also to the case mentioned by Mr Rowan, where induction transformers are to be used in a mine, I should like to

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ask him if there are any special conditions rendering the use of this apparatus advisable, as otherwise I should be inclined to condemn it, as unnecessarily complicating the arrangements. For mine work, my experience is, you cannot have things too simple.

In conclusion, I would remark that our strongest card in the advance of the use of all electrical apparatus is the education that is going forward so rapidly, and in which Scotland has always taken a leading part. Every kind of apparatus will be able to be made and worked for far less, when those using them understand their principles, and this is true of electrical apparatus above all others.

Mr JAMES GILCHRIST said that after the experiments made at Earnock to see whether an incandescent lamp fired gas (see Vol. III., p. 154), he was a little surprised to hear Mr Rowan say that in some of the experiments in South Wales the gas was not fired. He found from Mr Mordey's account that the incandescent lamp was put in the *bottom* of the box containing the explosive mixture, and that might be the reason why in that particular case it did not ignite the gas. Possibly the box was not filled. In the next experiment they did ignite the gas. When the experiment was made at Earnock they might remember that the lamp was put near the top of the box, the box being filled with gas from the bottom, and, to show it was full, tested with a safety lamp. Mr Sydney Walker, in his communication, said it was quite easy to prevent the sparks from wires firing gas, provided that the strength of the electric spark was not more than two volts, and he also said the sparks must pass through the gas in order to ignite it. If he understood aright that meant that they might bring two wires together in a body of gas and have a very large spark and not fire it, but if they had a thin stratum of gas then they would fire it. If an electromotive force of two volts would do this, then the most of the electric signals underground would at certain places fire gas. He stated at a former meeting (p. 222) that with a battery of seven cells he had fired the gas issuing from a common gas burner.

Mr HENRY AITKEN said this new science must impress them favourably if by its means they were able to get over the

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difficulty they encountered in attempting to transmit power. He would like to have information as to the best mode of carrying, in one instance 900 horse power for three miles and a half, and in another 800 horse power about a mile and a half. Having water power, he had almost made up his mind to adopt compressed air as a means of carrying the power from the water and to where he wanted it.

The PRESIDENT said he was very glad to hear that electricity was being applied to the transmission of the power to do work underground. They all knew that was a most important work in mining. He asked if there was any danger of accidents from people laying hold of the cable.

Mr ROWAN replied in the negative. The electric current was harmless if no greater tension than 150 volts was being transmitted. A man might take such a current through his body without experiencing any unpleasantness, though he might feel a slight tingling sensation.

The PRESIDENT asked what would be the result of laying hold of a conductor transmitting the power say to the haulage.

Mr ROWAN said it would depend on the potential at which the conductor was charged. Of course if it was carried through any place where men were passing or were working it probably would be protected by insulation.

The PRESIDENT instanced the conductor in connection with the Edinburgh Exhibition electric railway.

Mr ROWAN explained that there was no danger in that case.

Mr JAMES ANDERSON asked how the fatality occurred in connection with Czar's yacht "Livadia."

Mr ROWAN said an alternating current was used in connection with Jablochkoff candles in that case, and if such a current passed through a man's body, fatal consequences must follow. He wished to say, in reply to Mr Sydney Walker's question, that he did not know the details of the African mine installation, but he believed there were some special conditions which had led Mr Lorrain to adopt secondary generators in that case. He thought that Mr Walker had rather magnified the difficulties of applying electrical transmission. With regard to pumping, the electric motor was in no worse position than any steam engine producing

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rotary motion and driving pumps by cranks or eccentrics. He would be glad to give Mr Aitken the information which he desired.

The PRESIDENT closed the discussion, and on his motion a hearty vote of thanks was accorded Mr Rowan for his paper.

MR BURNETT'S ROLLER WEDGE.

IN reply to Mr Gilchrist the PRESIDENT explained with reference to the proposed trials at Hamilton Palace Colliery that Mr Burnett sent the machines and his father to superintend the operations, but that the latter, after making various inspections, had gone away and had not returned.

This closed the evening's discussion.

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NOTES ON PAPERS IN TRANSACTIONS OF KINDRED SOCIETIES, ETC.

Transactions of the AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Vol. 6, 1885.

ON A NEW METHOD OF CONSTRUCTING HORIZONTAL TUBULAR BOILERS.

By F. A. SCHEFFLER, Erie, Pa.

The recent improvements that have been made in rolling mill machinery, and the fact that large plates of steel, 16 feet long by 100 inches wide, can now be obtained, suggested the idea that the cylindrical portion of the shell of horizontal tubular boilers might be constructed of two plates only, and the following are some of the advantages claimed for this system of construction:—1st, By carrying the longitudinal seams about two inches above the flues there will be no seams exposed to the fire, except the lower half of the end plates; this is a positive advantage over boilers as at present constructed, where there are from four to eight seams exposed to the fire. 2d, By avoiding the exposure of the seams, a greater reduction is apparent in the chance of leakage around the rivets. 3d, The advantage of equal expansion and contraction is of great benefit, and the usual excessive strains are largely reduced. 4th, In cleaning the boiler, no question can be raised as to the benefit of a single plate on the bottom; there are no rivets for the lodgment of scale, sediment, &c., and there are no seams to interfere with a thorough scraping of the shell. 5th, There are no seams vertically, and the boiler must be stronger, as there are no holes punched for the rivets. The first boiler made on this principle was finished on 23d Sept., 1884, and was 5 feet diameter and 16 feet long, $\frac{1}{2}$in. thick of steel, and constructed in two plates. It was found that a greater degree of accuracy could be obtained in getting the rivet holes in direct line, and thereby the likelihood is greatly reduced that boilermakers will use the detestable drift-pin, that greatest of all evils in boilermaking. In the paper the superiority of steel over iron for boiler plates is discussed, and the preference given to steel, chiefly because steel plates have no grain to be considered in rolling them either lengthways or crossways, for their use in boilers; whereas, with iron, the peculiarity of its fibrous structure is an objection to the manufacture of large plates. When steel can be obtained for use in boilers having a guaranteed tensile strength of 60,000 lbs. per square inch, an elastic limit of 30,000 lbs., and which will bend down close, when cold, without fracture, it is very apparent that the superiority of steel over iron cannot be questioned.

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STEAM BOILERS AS MAGAZINES OF EXPLOSIVE ENERGY.

By R. H. THURSTON, Hoboken, N.J.

In this paper Professor Thurston gives a series of calculations relating to the magnitude of the store of energy in the masses of steam and water contained in steam boilers, which are rather startling. It is noted that the first attempt to calculate the amount of energy latent in steam boilers and capable of expansion by explosion was made by G. B. Airy, Astronomer Royal of Great Britain, in the year 1863, and by the late Professor Rankine at about the same time—papers by both on the subject being published in the same number of the "Philosophical Magazine" (Nov., 1863). In the paper by the Astronomer Royal, it is remarked that very little of the destructive effect of an explosion is due to the steam which is confined in the steam chamber at the moment of explosion. The rupture of the boiler is due to the expansive power—common at the moment—to the steam and the water, both at a temperature much higher than the boiling point, but as soon as the steam escapes and thereby diminishes the compressive force upon the water, a new issue of steam takes place from the water, reducing its temperature; when this escapes and further diminishes the compressive force, another issue of steam of lower elastic force takes place from the water, again reducing its temperature, and so on until the temperature of the water is reduced to atmospheric boiling point and the steam pressure to 0. Thus it is shown that it is the enormous quantity of steam so produced from the water during this continuous but exceedingly rapid operation that produces the destructive effect of steam boiler explosions. In Professor Rankine's paper the subject is dealt with by the application of the formulæ for the transformation of heat into work; and it is shown that the energy developed during this method of expansion depends solely upon the specific heat and temperature at the beginning and the end of the expansion, and has no dependence whatever upon any other physical property of the liquid. Professor Thurston limits the scope of this paper to the investigation of the quantity of energy stored in some familiar and commonly used forms of steam boilers, and the following are shortly some of the remarks he makes on the subject:—A steam boiler is a vessel in which is confined a mass of water and of steam at a high temperature, and at a pressure greatly in excess of the surrounding atmosphere. The sudden expansion of this mass, from its initial pressure down to that of the external air, occurring against the resistance of its shell, or other masses of matter, may develop a great amount of work by the transformation of its heat into mechanical energy, and may cause, as daily occurring accidents remind us, an enormous destruction of life and property. The enclosed fluids consist, in most cases, of a small weight of steam and a great weight of water. Under such conditions the energy contained in the water is greatly in excess of that contained in the steam. A pound of steam at a pressure of six atmospheres (88·2 lbs. per square inch), and at its normal temperature (319 F.), has stored in it about 75 British Thermal Units, or nearly 600,000 foot lbs. of mechanical energy per unit of weight in excess of that which it contains after expansion to atmospheric pressure. A pound of water accompanying that steam, and at the same pressure, has stored within it about one-tenth as much available energy. Nevertheless, the disproportion of weight of the two fluids, in an ordinary boiler, is such as to make the quantity of energy stored in the steam quite insignificant in comparison with that stored in the water—for instance, in an ordinary, plain cylindrical boiler, 30 inches in diameter and 30 feet long, the boiler weighs a little over a ton, and contains more than twice its weight of water. The water at a temperature corresponding to that of steam, at 100 lbs. pressure per square inch, contains over 46,600,000 foot pounds of available explosive energy; while the steam, which has but one-fifth of one per cent. of the weight of the water, stores about 700,000 foot pounds, giving a total of 47 million foot pounds, sufficient to throw the boiler four miles high, with an initial velocity of 1100 feet per second. This type of boiler, from its simplicity and strength of form, is a very safe one; still, when it does explode, the consequences are usually exceptionally disastrous, on account of the large quantity of water contained in it. Some interesting remarks are

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made on cases of exploded boilers which Professor Thurston has been called upon professionally to investigate, and from his experience he concludes that the boiler which will have the smallest destructive effect in the event of explosion is one in which, as in the water tube boiler, the contents are as much sub-divided as possible—a violent explosion can only come of the general disruption of a boiler and the instantaneous liberation at once of large quantities of steam and water. The destructive effects of steam boiler explosions, and the singular mystery that has been supposed to surround their causes, invest this subject with extraordinary interest, and probably no subject within the whole range of the practice of the engineer has demanded or has received more attention than this, and probably no such subject is to-day less satisfactorily developed in theory, and less thoroughly investigated experimentally.

J. P.

MECHANICAL PROPERTIES OF CORK.

On Friday, April 9th, Mr William Anderson delivered a lecture at the Royal Institution "On New Applications of the Mechanical Properties of Cork to the Arts." The lecturer began by demonstrating experimentally that in solid substances no appreciable change of volume resulted from change of pressure; even india-rubber was shown to be extremely rigid. Cork, however, appeared to be a solitary exception to this law, being eminently capable of cubical compression, both from forces applied in opposite directions and from pressure from all sides, such as arose when the substance was immersed in water and subjected to hydraulic pressure. The cause of this anomalous and valuable property of cork was then investigated, and it was shown to arise from its peculiar structure, which rendered it, in many respects, more like a gas than a solid. Cork was composed exclusively of minute closed cells, the walls of which were readily permeated by gases, but were impervious to liquids. The cells were filled with air, which, when pressure was applied, yielded readily, and expanded again when the pressure was removed. The impermeability of the cells to liquids prevented cork from getting waterlogged when exposed to such fluids in bottles and in the new applications devised by the lecturer; and this property, combined with permeability to gases, rendered cork superior to india-rubber in waterproof clothing, because it permitted transpiration while excluding the wet. Mr Anderson next proceeded to explain some of the practical applications which he had made. The first was the substitution of cork for air in the air-vessels of water-raising machinery. This was illustrated by a hydraulic ram which worked a fountain about 10 feet high in the lecture room. Another application was the storage of a portion of the energy of the recoil of guns and employing it for the purpose of running them out when ready for firing. The gun-carriage was very much like that commonly in use with hydraulic compressors, but the water in the cylinders was driven by the recoil into a vessel filled with cork, which was thus compressed. The cylinder was separated from the cork vessel by an automatic valve which prevented the reflux of the water. As soon as the gun was loaded a tap was opened, the cork was then free to expand and liberate the water back into the cylinder, so running out of the gun. The lecturer pointed out that this method of using cork would allow of a gun being run out up an incline. The system was peculiarly adapted for naval use, where inclined planes became inoperative in the event of a vessel having a list in the opposite direction. The lecture, which was profusely illustrated by means of diagrams and experiments, certainly placed cork in a new light before the scientific world, and indicated fresh and extensive fields for its use.—*Engineering*, 16th April, 1886.

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REPORT OF THE COMMITTEE ON A UNIFORM SYSTEM OF TESTS FOR CEMENT.

This is a report of a committee appointed to devise a uniform system of tests for hydraulic cement.

The system proposed is not yet a perfect one, but it is hoped will enable the experiments carried on in different parts of the country to be satisfactorily compared.

The test for tensile strength on a sectional area of one square inch is recommended—which, if properly made, is considered a good though not a perfect indication of the value of the cement.

The compressive test is more valuable in point of fact, but the appliances for crushing are somewhat cumbersome and expensive.

The adhesive test is considered to be untrustworthy.

Fineness.—The strength of a cement depends on the fineness to which it is ground, especially when mixed with a large quantity of sand. It is advisable that tests be made with cement that has passed through a No. 100 seive with 10,000 meshes to the inch. The finer the cement, if otherwise good, the larger quantity of sand it will take, and the greater its value.

Checking or Cracking.—The test for checking or cracking, though simple, should never be omitted. It is as follows :—Make two cakes of neat cement two to three inches in diameter, about half an inch thick, having thin edges. One of these cakes when hard enough, should be put in water and periodically examined to see if it becomes contorted or cracked, such contortions or cracks shewing the cement is unfit for use at that time.

The other cake should be exposed to the air and the colour observed, which, if the cement is good, will be uniform. The latter test indicates the quality better than the former.

Mixing, &c.—The sand and the cement should be perfectly dry, and their proportion with water should be accurately determined by weight. The proportion of water used varies according to the fineness of the cement, &c. The mixing must be rapid and the mortar put into moulds without ramming. The moulding to be complete before incipient setting begins. At the end of twenty-four hours the briquettes to be immersed in water.

An average of five briquettes is recommended to be made for each test, only those breaking at the smallest section to be taken, the test being made immediately after being taken out of the water. The stress should be applied at a uniform rate of about 400 pounds per square inch per minute.

Setting.—The various cements may be divided into two classes, viz.—quick setting, or those that set in less than half an hour, and slow setting, or those that take half an hour or more to set. The rapidity with which a cement sets furnishes no indication of its strength.

Sampling.—The committee recommend the sampling of about every fifth barrel where the cement is to be used for foundations or the backing of walls; but in a very important work it is requisite that every barrel should be tested.

Sieves.—To ascertain the fineness of cement three sieves are recommended, viz.—No. 50 (2500 meshes to the sq. inch), wire to be No. 35 Stubbs wire gauge. No. 74 (5476 meshes to the sq. inch), wire No. 37 wire gauge. No. 100 (10,000 meshes to the sq. inch), wire No. 40 wire gauge.

For sand it will be convenient to use two sieves, No. 20)400 meshes to the sq. inch), wire to be No. 28. No. 30 (900 meshes to the sq. inch), wire to be No. 31.

Standard Sand.—The sand recommended for the tests is crushed quartz, the degree of fineness to be such that it will pass through a No. 20 and caught on a No. 3) sieve. It is only to be used for purposes of comparison with local sands.

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Moulds.—The moulds should be made of brass or iron. The clips on the testing machine should be made so as to allow as much metal surface to be in contact with the briquettes as possible.

No special machine is recommended, as those in common use are of good form and give accurate work. A. L.

THE ABT SYSTEM OF RAILWAYS FOR STEEP INCLINES.

By WALTON W. EVANS, M. Am. Soc. C.E.

This is a paper on a system of railway upon which a great many inventions and improvements have been made by Mr Roman Abt, of Switzerland.

The system is adopted in many parts of the Continent of Europe and America, and is only used where the gradients are too steep to admit of the construction of the road being carried out under the ordinary method. It consists of a number of rack rails placed side by side in the centre of the road, each of the elementary parts being a bar of given length provided with teeth, such as is to be seen on any ordinary rack. The bars are held together by iron or steel chairs or bolts. The chairs, being placed at regular intervals, keep the bars laterally distanced from one another, and through these chairs the whole is firmly secured to the sleepers. Mr Abt lays the various bars of which his rack rail is composed with broken joint. They are also laid with broken pitches—that is, the teeth of the side-by-side bars are arranged in the form of steps. This arrangement enables the simultaneous contact of several teeth of the pinion with the different bars of the rack rail. This inter-locking of several teeth offers an increased security against fracture.

The pinion is constructed of as many separate discs as there are bars in the rack; and also its various discs are in elastic connection with the shaft by means of inserted springs, this admitting of the discs having a small limited motion to one another, and also counteracting any small inaccuracies due to the manufacture or mode of fastening, or expansion and contraction due to temperature. At sixteen miles an hour the motion obtained is smooth and free from irregularities, not the slightest noise being observed—the pinion working as silently in the rack as the regular adhesion drivers on the smooth rails.

A characteristic property of Abt's rail consists in its economic accommodations to the gradients of the road—the steeper the gradients, the greater number or thickness of the bars of which the rack rail is composed. Crossings and switches are made and worked similar to those on ordinary lines.

Locomotives.—It was found, in building locomotives to work on this road, where steep gradients were the rule, a number of points had to be taken into account, viz., that traction and speed must vary in inverse proportion—large traction small speed, small traction large speed; that, where practicable, the engine to work on purely adhesive principles, without the aid of the pinion.

The type of locomotive suitable to work under those conditions may be described as one of the ordinary make and of moderate weight, with mechanism having an independent set of steam cylinders suitable to work the pinion apart from those required to work the adhesion drivers. The adhesion drivers act independently from the pinion, and only work alone on flat portions of the road, and in conjunction with the pinion on the steeper gradients of the line.

The speed adjusts itself according to the total traction and the steaming qualities of the boiler—the engine developing its full powers under the most varying and trying circumstances.

An important reason for utilising the natural adhesion of the locomotive exists in the fact that even on gradients of 1 in 9 the traction due to adhesion alone is from one-half to one-third of the total power exerted. This enables the rack rail to be relieved of a considerable amount of strain. The main feature, then, of Abt's locomotive consists in the additional mechanism necessary to work the pinion, with which any good adhesion

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engine, if provided, would thus become suitable for a rack railroad. As the rack rail is considerably higher than the smooth rails, a pinion of a small diameter is all that is required, the shaft being driven from the separate cylinders.

Entering Rail.—The rack rail being only laid where the gradients are steep, it was found necessary that a special entering rail should be made, so that the pinion would take the rack without slackening speed. The rail used for this purpose is about 10 feet long, hinged to the fixed part of the rack, and wholly resting on strong spiral springs. The teeth towards the free end gradually diminish in height, and when the locomotive is passing over it, and before the steam is admitted into the extra cylinders, the revolving of the pinion commences. This is caused by the friction between it and the yielding rack rail. The wheel is turned on its axis with little or no strain on the teeth, and before many feet are travelled over a true inter-locking of the rack and pinion takes place.

The author goes on, further, to take note of the application of this system in various countries. He points out that on a gradient of 1 in 20 the ordinary rack rail locomotive will draw a 130 ton train at a speed of about 7·2 miles per hour, or a train of 180 tons, with one engine pulling and another shoving, can be taken up a gradient of 1 in 10, and the weight being reduced, a much steeper incline can be overcome. A. L.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—March, 1886.

BEHAVIOUR OF CEMENT MORTARS UNDER VARIOUS CONTINGENCIES OF USE.

In this paper, the author desires to call attention to the necessity of further investigation into cements, &c., as follows:—1st, Behaviour while setting, either as to expansion or contraction; 2nd, compression at various ages under increasing loads; 3rd, the same observations with various mixtures of sand; 4th, the same for concretes and lime mortars; 5th, to make the results available, examinations of the same kind should be made on bricks, stone, or other building material; 6th, the measurement at compression of walls of buildings or other masses of masonry at various stages of construction—the temperature at time of observation being noted; 7th, it is desirable that the members' experience should be recorded as to the setting of mortars in frosty weather, and the best method to pursue during that time.

The desirability of such observations may be seen when new work is added to old; when concrete is added to masonry or other building material; or when calculating the behaviour of an arch of considerable dimensions on withdrawal of centering.

The author points out that a member in a previous paper shews that there is expansion; and, on the contrary, another gives his experience with a cylinder filled 50 feet with concrete, the concrete contracting two inches without any superposed weight.

The question is then asked, is there a preliminary expansion due to crystallization and a subsequent contraction, or has the amount of water used something to do with it

A. L.

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The Journal of the IRON AND STEEL INSTITUTE. No. 2. 1885.

ON THE IRON TRADE OF SCOTLAND.

By F. J. ROWAN, Glasgow.

This paper, which may be said to be a review of the history of the Iron Trade in Scotland, was read before the Iron and Steel Institute at their meeting in Glasgow in the autumn of last year. According to the author, the earliest intimation of Scottish iron-making of which there is any reliable information is contained in a reference in an Act of the Scottish Parliament in 1686, "to the trade of founding lately brought into the kingdom by John Meikle, for casting of balls, cannons, and other useful instruments." The first furnaces built in Scotland were one at Goatfield and one at Bunawe, both in Argyleshire, about the year 1750. These were followed in 1759 by the Carron Ironworks, then follows the Wilsontown Ironworks in 1781; Muirkirk and Omoa in 1787; Clyde Ironworks in 1788; Devon and Glenbuck in 1791; Balgonie (Fife) and Calder in 1801; Shotts in 1802, and Monkland in 1805. From the year 1830 till about 1840 there were no less than 24 ironworks established for the manufacture of pig iron, and numerous malleable ironworks were erected during the same period, the greater number of which are still in existence. At the date of the paper, there were in Scotland 143 blast furnaces, of which 92 were in blast, making on an average 200 tons each per week. At the end of the year 1884 there were 367 puddling furnaces built, of which there were 269 working and producing on an average 732 tons per furnace annually. The annual make of pig iron in Scotland about the year 1830 was 37,500 tons, but at this date, which marks the introduction of hot blast at Clyde Ironworks, a remarkable rate of increase set in. In 1836 the production had doubled; in 1839, it had reached five times the extent of the output of 1830; and in 1843 it reached eight times that quantity; in 1845, the extent of the manufacture was thirteen times that of 1830, and it increased very steadily from that date till 1870, when the largest annual production ever recorded in Scotland was reached (1,206,000 tons).

The prices of pig iron have fluctuated greatly. In 1844, a severe commercial depression brought the price to 40s and under, but by December of that year 65s had been reached; prices rose in 1845 to 120s per ton, and averaged 80s for that year. The average price for 1846 was 72s 6d. 70s was the average price for the first nine months of 1847. A commercial crisis again occurring, the prices fell at the end of the year to 45s. Periods of depression existed from 1848 to 1852; from 1858 till 1866, with a respite in 1863; from 1866 till 1871; and from 1877 till the present time, with a break in 1879 and 1880. The prices in 1872 and 1873 were unusually high; in February, 1873, the highest price ever reached for Scotch pig iron was recorded at 138s per ton, 129s having been reached in August, 1872. The output of ironstone in Scotland has been practically stationary for many years, but since 1881 it has begun gradually to decline. In 1860, Scotland produced 26·7 per cent. of all the ironstone raised in the United Kingdom; in 1870, 24·4 per cent; in 1881, 14·9 per cent; and in 1882, 13·34 per cent. This marked falling off is no doubt partly due to the influence of the steel trade, which has caused an increasing quantity of the non-phosphoric ores of Spain and Africa to be imported. Appended to the paper there are six tables showing furnaces in blast, quantities of iron made, shipments, prices, annual make per furnace, coal used per ton of iron, ore used per ton of iron, &c. There are also four diagrams, which show at a glance the annual make and stocks of iron, the prices at Glasgow, and the outputs and prices of coal, and the rate of miners' wages from 1849 till 1884.

THE RISE AND PROGRESS OF THE SCOTCH STEEL TRADE.

By MR JAMES RILEY.

Previous to the year 1862, the steel trade of Scotland had not attained to any great importance, the manufacture being confined to comparatively small quantities of crucible

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steel by the Monkland Iron and Steel Coy., and one or two other firms: indeed up till the present time the manufacture of crucible steel in Scotland is only something like 1500 or 1600 tons yearly.

Except a very crude trial which was made at Coats Ironworks, by Mr Jackson in 1857, the first attempt to introduce the manufacture of steel on the Bessemer system was made by the late Mr Rowan, who erected in 1862 what was then considered to be the most perfect plant in existence for this purpose, having two 3-ton converters and all the necessary apparatus for working them economically. Considerable difficulties were experienced in working the process, and, chiefly from want of demand, although the quality was excellent, the manufacture rarely exceeded 40 tons of ingots per month. These works were continued by the Messrs Rowan till 1872, when they were transferred to a company which ultimately ceased operations in 1875. Since then, and until quite recently the Bessemer process has had no place in Scotland as a manufacturing industry. No doubt the unsuitability of Scotch pig iron on account of the phosphorus it contains, has had a good deal to do with this, but by the application to the converter of the basic lining of Messrs Thomas and Gilchrist, there is a reasonable hope that the locally manufactured pig iron may be converted into good steel, and there is now a prospect of its being worked on a large scale. A finely-equipped work for the production of basic steel was put in operation a short time ago by Messrs Merry & Cuninghame at Glengarnock. The Glasgow Iron Coy. have also erected a large establishment of the same kind at their Wishaw works, and both works combined are capable of producing 100,000 tons per annum of basic steel. Notwithstanding some rather unfavourable experiments with purple ore, made by Messrs Rowan in 1870, the Steel Company of Scotland was formed in 1871 for the manufacture of steel by the Siemens process out of "blue billy" or purple ore, charged direct into the furnace, and melted without having been previously made into pig iron in the blast furnace. So sanguine were the promoters of the Steel Company that the process would prove a successful one, that they entered into a contract with the Tharsis Company for over 20,000 tons of purple ore at the price of 25s per ton delivered at Hallside works. About 170 tons of puddled ball iron was made by this process. The cost, however, was so great that the furnace was stopped and the whole of the plant removed. Meanwhile, some open hearth furnaces had been erected at Hallside, which were added to yearly as the demand for steel increased, and up till 1879 the Steel Company had a monopoly of the steel trade of Scotland. Their make in 1873 was 1200 tons; in 1874, 1800 tons; in 1875, 23,000 tons; in 1876, 32,000 tons; in 1877, 36,000 tons; in 1878, 42,000 tons. The manufacture of ship plates was begun in 1877, Messrs J. Elder & Co. building two steamers of steel, and Messrs J. & G. Thomson commencing one. In 1879, a large and constant development of production set in. Messrs Beardmore at Parkhead and Messrs Williams, Wishaw, entered into the trade. These were rapidly followed by the Mossend Iron Coy., Messrs Colville & Sons, Messrs Wyllie & Coy., Messrs Gray & Watt, The Govan Steel and Forge Coy., The Clydesdale Iron Coy., and the Mount Vernon Steel Company. The output from these works brought up the quantity of ingots made in 1883 to 230,000 tons. Contemporaneously with this development of production, demands for increased sizes of plates and bars required constant additions to the power and strength of engines, mills, and machinery to such an extent that they will probably bear comparison with those of any other country. The course of prices has been almost uniformly downwards. In 1876, the price of ship plates was £20 per ton, and they fell to £6 15s at the end of 1884. To meet this great fall the utmost economy must have been exercised at all the works where this important manufacture is carried on, and most people will heartily join the author in hoping that, in future, the increase in the applications of steel may cause a sufficient demand to keep all the works occupied in a remunerative manner.

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ON THE RECOVERY OF TAR AND AMMONIA FROM BLAST FURNACES.

By Mr William Jones, Langloan Ironworks.

This is a paper descriptive of the various methods in use for the recovery of tar and ammonia from the gases of blast furnaces. With the exception of the works of R. Heath & Sons at Norton, near Stoke-on-Trent, this economy is practised only at the Scotch ironworks. The author divides the process into two methods:—1st, Where the first step in the process is the condensation of the gases; and 2nd, where the gases are treated with acids when in a hot state. In the first category are the Gartsherrie process, the Dempster process, and the Henderson process; and in the second, the Summerlee process and the Langloan process. Where adequate plant is provided for the work, the results, as far as the yield of ammonia is concerned, are said by the author to be about equal—viz., about 22 lbs. of sulphate per ton of coal charged into the furnace. A larger yield of tar, however, is said to be got by the condensation process. The following is an analysis of an average Splint coal used for blast furnace purposes at Gartsherrie — analyst, Dr Wallace:—Carbon, 70·05 per cent.; hydrogen, 5·24; oxygen, 12·08; nitrogen, 1·36; sulphur, ·75; ash, 3·80; water, 6·72; and the following may be taken as the composition of blast furnace gases by volume:—Carbonic oxide, 25 to 30 per cent.; carbonic acid, 3 to 8 per cent.; hydrogen, 5 to 7; marsh gas, 2 to 4; nitrogen, 52 to 60; and the average temperature at which they issue from the furnace is 500 F. The volume, per ton of coal is 125,000 cubic feet at 60° F. The author estimates the outlay for plant to be about £7500 per furnace on the condensation principle, and at £2125 per furnace on the hot washing principle. A pretty complete description of each of the methods is given, and the paper is fully illustrated.

THE FORTH BRIDGE.

By Mr B. Baker, M.R.C.E., London.

During the last 22 years no less than three Acts of Parliament have been obtained for bridging the Forth. About 21 years ago, the first bridge was authorised to be built at a point about five miles above the present one, but no suitable foundations could be reached, although borings were made upwards of 200 feet deep in the middle of the river. Nothing but soft mud was found, and the undertaking was abandoned. In 1873, another Act was obtained for a bridge at the present site. Sir Thomas Bouch prepared a design for this bridge on the suspension principle, with towers 665 feet high; but the fall of the Tay Bridge shook public confidence in this bridge, and it also was abandoned. The railway companies interested then ordered a final reference of the whole question to their respective consulting engineers, with the result that the present cantilever bridge, designed by Mr Fowler and the author in consultation with Mr Harrison and Mr Barlow, was substituted, and, the necessary Parliamentary powers having been obtained in 1882, the works were commenced in January, 1883, by Messrs Tancred & Arrol, the contractors. The total length of viaduct included in the contract sum of £1,600,000 is about one and a half miles, and there are two spans of 1710 feet each, two of 675 feet each, fifteen of 168 feet, and five of 25 feet. Including piers, there is one mile of main spans and half a mile of viaduct approach; the clear headway is 150 feet above high water, and the tops of the great cantilevers are more than 200 feet higher still. There will be about 45,000 tons of steel in the superstructure of the bridge and 120,000 cubic yards of masonry in the piers. The rolling load provided for in the construction of the bridge is (1) trains of unlimited length on each line of rails weighing one ton per lineal foot; (2) trains on each line made up of two engines and tenders, weighing in all 142 tons, at the head of a train of 60 coal trucks of 15 tons each. The wind provided for is a pressure of 56 lbs. per square foot striking the whole or any part of the bridge at any angle with the horizon, the total amount on the main spans being estimated at no less than 7900 tons. In practice only two trains, weighing 800 tons in all, would be on this length of bridge at the same time,

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so the wind pressure—if such a hurricane as 56 lbs. per square foot could ever occur—would be ten times as great as the train load. Under the combined stresses resulting from the test load in the worst position and the heaviest hurricane, the maximum stress on the steel will not exceed 7¼ tons per square inch on any portion of the structure, and on members subject to great variation in the intensity and character of the stress, the maximum will not exceed 4 tons per square inch. In referring to the sinking of the caissons, Mr Baker notices a curious circumstance which occurred during the operations at the north-east pier. When the caisson was at a depth of 57 feet from the surface of the water, it was found convenient to have an air pressure of about 30 lbs. per square inch inside; but, after passing through a considerable thickness of silt, it only required 18 lbs. per square inch of air pressure to prevent the water coming in, although the depth was then 90 feet. In conclusion, Mr Baker gives the approximate value of the plant now at the Forth Bridge at £250,000, and the work executed at £600,000. In illustration of the paper, there is a plate showing a comparison of different existing bridges with the Forth Bridge. J. P.

Transactions of the NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS. Vol. XXXV.

THE TESTING OF SAFETY LAMPS; AN ACCOUNT OF EXPERIMENTS MADE BY PROFESSORS KREISCHER AND WINKLER.

By PROFESSOR BEDSON.

The experiments here under review were carried out at the instance of The Saxon Royal Commission intrusted with the Revision of Mining Regulations in that state. Professor Bedson starts with the avowed intention of considering these experimental results mainly in their bearing upon the Wolf Safety Lamp. Following the plan of the original report he shortly explains the scientific theory of flame, and passes on to consider the safety lamp as a "light producer." The factors which enter into this problem are, the illuminating agent, the form of burner, and the method of supplying the air. The advantages and disadvantages of rape oil, of rape oil mixed with petroleum, and of benzine are shortly detailed. From a consideration of the structure of flame the theoretical result is deduced—that burners formed of material of low conductivity favour the development of the full lighting power of the illuminant; and experiment with steatite wick-holders for consumption of benzine are suggested.

The safety lamp as "Safeguard and Indicator" forms the second section of the paper. The general result of the experiments is markedly in favour of supplying air to the lamp from below in place of the commoner method of from above, and that in relation both to safety in explosive mixtures and delicacy in detection of small percentages of fire-damp. Safer because both flame and cap were extinguished in mixtures above 7 per cent. except with 15 per cent. whereas with air admitted above, the cap as a rule continued to burn after the lamp flame was extinguished; and more sensitive because 1 and 2 per cent. of gas in air produced a more characteristic change on the flame. Using benzine the indications of the presence of fire-damp are pronounced, and it is easily extinguished by explosion inside the lamp. It offers peculiar facilities for testing with a "reduced flame," which is not only the safest but most reliable. Rape oil is less sensitive with an ordinary flame, but if the difficulty of reducing it is successfully overcome it yields not even to benzine in delicacy as an indicator. For this purpose a mixture of rape oil and petroleum with a normal flame is very sensitive to small percentages of fire-damp; but with higher proportions its unsteadiness is a fatal objection.

The suitability of the safety lamp as a means of testing the percentage of fire-damp or explosive gas in any atmosphere is most seriously affected by the nature of the gas itself. Not only is the colour of the cap dependent upon the particular gas, but a com-

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paratively small percentage of other hydro-carbons, ethave for example, reduces materially the percentage of fire-damp necessary for the most violent explosion. Gases, such as carbonic acid, which simply act as diluents have no very marked effect on the flame of the safety lamp beyond the necessary result of modifying the percentage of fire-damp present in the atmosphere.

It seems at first sight very much like the gratuitous introduction of a new danger to use such a highly inflammable liquid like benzine in a safety lamp, but experience proves such a fear illusory. The gradual heating of a lamp to 183° Fahrenheit only resulted in the extinction of the flame, when the condensed benzine, which had collected on the gauze, was ignited on the outside without the flame being communicated through the gauze to what had collected inside. Such a temperature is only possible with the lamp in an explosive mixture. In an experiment with coal gas, when the benzine boiled in the lamp, it was simply extinguished without explosion.

On a comparison of the illuminating power and proportional cost the result is favourable to the benzine lamp with admission of air from below. The mere change to admission of air above increases cost 1¼ times.

The last section of the paper gives the method of testing and results of experiments with lamps in explosive mixtures of fire-damp and coal gas. The behaviour of the flame of the lamps in atmospheres containing various percentages of explosive gas from 1 to 16 per cent. is verbally described and graphically shewn in the accompanying plates.

ON A PORTABLE ELECTRIC SAFETY LAMP FOR MINERS.

By J. W. Swan.

The author says he has for four years had the idea of such a lamp in his mind, and in this paper he describes the embodiment of the idea. It is an incandescent lamp supplied by a seven-cell secondary battery within itself, capable of supplying a light of 2 candle power for 10 hours and 1½ candle for 2 hours longer. A new charge is then necessary and this is accomplished by connecting the battery with a dynamo which may, with a five-horse-power engine, charge 300 lamps simultaneously. The carbon filament is placed on the side completely outside the cylinder which contains the battery, and protected with a strong bull's-eye glass. In this way the rays of the lamp illumine a complete hemisphere and additional light may be thrown on the roof by canting the lamp, which can be safely done. Although the exact weight is not stated it appears to be over 6lbs., and this must still be a serious drawback under the general conditions accompanying the use of such a lamp. Even that weight is likely to be increased because Mr Swan, in order to meet a no less serious objection, proposes to add a contrivance for the detection of fire-damp. Whether the proposed detector is an invention of his own, or one of those already patented, he does not state. The lamp is 10 inches high over all and 4 inches in diameter. J. H.

THE SCHOOL OF MINES QUARTERLY, Vol. VI., No. 4.

MASONRY SUPPORTS FOR HANGING WALLS AT THE TILLY FOSTER IRON MINES.

By Louis G. Engel.

The Tilly Foster iron ore deposit is of a peculiar lens shape, narrower at the surface and at the lowest level reached than in the middle, and only about 400 feet long on the strike of the deposit. At the surface the inclination is about 66 deg., but as it descends it approaches the vertical; so that the main shaft, which slopes at 66 deg., starts in the foot wall at the surface, passes through the ore deposit, and enters the hanging wall at the 500 feet level. The method of working was formerly by rooms driven along the deposit, with pillars left to support the roof; but a cave occurred, completely filling the open workings, and compelling the adoption of a new system of mining. At intervals of 100 feet levels are driven from the shaft completely round the ore body, with the foot

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and hanging walls forming one side of the level, according as it is on the under or upper side of the deposit. Rooms are driven through between the level at the foot wall and the level at the hanging wall, and these rooms are then raised till they are within 25 feet of the level above. They are so placed that each room is exactly under the corresponding room of the level above, and separated from it by 25 feet of solid ore. The hanging wall is about 80 feet from the foot wall at the normal thickness of the deposit, but by faulting, this distance rises to 160 feet in part of the mine. The hanging wall is supported by pillars, which contain about 75 per cent. of the total deposit. As the upper levels became exhausted, so far as the resources of the above method of mining were available, the problem of how to recover this large proportion of ore in pillars presented itself, and was soon resolved into—What is the most economical and efficient method of supporting the hanging wall while the pillars are being removed? Two proposals, to uncover the entire mass, and to rob the pillars while the hanging wall took care of itself, were abandoned as soon as made. A third proposal to fill the entire space originally mined with concrete, and then to remove the pillars, was condemned as too expensive. The plan adopted was that of building with concrete raised on arches thrown from wall, certain of the rooms before-mentioned to an extent sufficient for the support of the hanging wall. It was necessary to execute the work concurrently with the ordinary operations of the mine and continuously throughout the year. The severity of the frost in winter prevented the making of concrete on the surface with safety, and in addition, the stone to be used was already in the mine. It was therefore determined to mix the concrete underground and raise it to its position when the arches had been built, in place of filling the rooms from above. The first arch formed had a span of about 90 feet, with a rise of 15 feet, and was built of brick and made 3 feet in depth. A shaft was left in the arch and concrete above, through which materials were raised by steam power from the mechanical mixer placed under the arch. To avoid interference with the working of ore in the lower levels, the first pillars were built above the 300 feet or highest level off the shaft, but a continuous pillar will afterwards be raised from the 500 feet level up under one already built, thus forming a solid mass of concrete nearly 300 feet in depth and 1700 feet in horizontal sectional area over an arch at the 500 feet level. This pillar is also meant for a barrier between the two sections of the workings, and the other pillars are, comparatively, mere struts of concrete in the various rooms. The estimated cost, based on the work already done, is given in detail, and amounts to 46 cents per ton of ore recovered. The paper is very elaborate, giving descriptions of the deposit, the method of working, and the details of the machinery and apparatus used in building the pillars, from the rope saddle on the sand chute to the mechanical concrete mixer. The illustrative drawings are beautifully done, but the degree of delicacy and fineness attained by the photo-gravure process has impaired their value considerably, inasmuch as the bulk of the explanatory printing is only readable with the aid of a glass.

J. H.

Transactions of the CHESTERFIELD AND MIDLAND COUNTIES INSTITUTION OF ENGINEERS. Vol. XIV., Parts 4 and 5.

Several short papers and discussions fill up these two issues of the transactions. The first contains a two days' excursion of the Institution to Leicestershire, among the granite quarries of Charnwood Forest. The geological history of the district is treated in a short paper mainly of local interest; but indicating one or two geological problems of some importance.

Mr P. M. Chester describes shortly the character and construction of "The Locked Coil Wire Rope," without giving any opinion thereon; and only mentioning one case where they have been tested in actual working. Nothing more was elicited in the discussion of this paper as to work done; but an agent of the makers answered several practical objections and questions, and gave information concerning flexibility, which is claimed as a special feature of the invention.

Mr J. C. Jefferson supplements a former paper on Meinicke's system of balance ropes,

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as applied along with flat winding ropes. The same author describes a "Self-Timing Anemometer," by Davies of Derby. The principle is that the pressure of the air current on the ordinary fan wheel of an anemometer is balanced by a spiral spring, the tension of which due to a given velocity having been ascertained by experiment is marked on a dial in feet of air current per second. J. H.

Transactions of the MIDLAND INSTITUTE of MINING, CIVIL, and MECHANICAL ENGINEERS. Vol. X.

ON THE DE BAY VENTILATOR.

By JOHN NEVIN.

Centrifugal ventilators have almost exclusively found favour in this country when mechanical means of ventilating mines have been adopted. Among those machines depending upon the application of a different principle the De Bay ventilator is one of the most recent. The inventor propels the air by the action of an archimedian screw, or rather two revolving in opposite directions, but propelling the air along the same line. The author describes a De Bay ventilator erected at Mirfield Colliery, and compares the work done thereby with the performance of various centrifugal ventilators in common use. He compares the useful effect of a De Bray, 8 feet diameter, with that produced by a Schiele, a Waddle, a Guibal, and a Gunther, at equal velocities of the tips of the eaves, with results favourable to the De Bay. Whenever the percentage of useful effect is stated, it is certainly very high; and the cost of the necessary buildings for the De Bay is small, compared with what is required for any of the above-mentioned fans, but experience of the former is much too limited to admit of any attempt to compare their relative durability

The same issue of these Transactions contains a short paper on the "Mechanical Telephone," by Sydney F. Walker, wherein he describes that instrument, the principle on which it acts, and the conditions necessary to secure satisfactory results therefrom.

J. H.

Transactions of the AMERICAN INSTITUTE of MINING ENGINEERS. Sept. 1885.

THE GEOLOGY OF NATURAL GAS.

By CHARLES A. ASHBURNER.

This paper gives in a simple and common-sense way a short review of the facts, so far as known, relating to the occurrence of natural gas in the United States of America, and an impartial criticism of some of the theories arising round a subject of at present immense, but, it is to be feared, fugitive importance to certain localities in the States—a subject at first blush weirdly strange as a tale of the Arabian Nights.

The existence of natural gas-springs in Pennsylvania and the adjoining States west of the crest of the Alleghany Mountains appears to have been known to the earliest settlers; but it is supposed that only in 1821 was gas first obtained from a well at a place called Fredonia, and here, while passing in 1824, must General Lafayette, whose eyes had gazed on the lurid blaze of the first French revolution, have seen burning this strange earth product.

The strata of the extensive oil and gas regions lie almost horizontally, the dip being from 14 to 60 feet per mile, and the strata productive of natural gas are found in the lower part of the Carboniferous zone and in the Devonian zone, but gas has been got from strata as low as the Lower Silurian limestone.

As to its origin, it appears that the gas is closely related to petroleum, and that their origin is due largely to the same cause—the decomposition of animal and vegetable life. The general conditions upon which the occurrence of the gas seems to depend are:—(*a*) The porosity and homogeneousness of the sandstone reservoir; (*b*) the extent to which the strata above and below the gas-sand are cracked; (*c*) the dip of the gas-sand

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and the position of the anticlines and synclines; (*d*) the relative proportion of water, oil, and gas contained in the gas-sand; (*e*) the pressure under which the gas exists before being tapped by the wells.

Although it is necessary for the existence of gas and oil that there should be suitable strata to act as a reservoir, it is far from following that gas must occur where such strata are found. Where the strata have undergone a folding and disruptive process by which gas under pressure might escape, there it is natural to find no gas. "The Anticlinal Theory," which places the gas on the anticlines of the strata, may have some truth in it, but is shown by numerous examples of wells in synclines to fall short of confirmation in actual practice. J. H. R.

Transactions of the AMERICAN INSTITUTE of MINING ENGINEERS. May 1886.

THE ANTICLINAL THEORY OF NATURAL GAS.

By H. M. CHANCE.

What a delightful subject this natural gas is for the imaginative scientist to revel in so many simple and plausible theories can be founded thereon, each so entirely satisfactory in its own way, so charmingly varied, so conflicting even, to the verge almost of bewilderment to the novice. One man says that down in its native depths it exists in a gaseous form, and acts obedient to the laws of gases; another says it has such a weight upon it that it must needs assume the gravity of a liquid; but no American has yet set it down as a body possessed of solidity. Another reveller would have it mixed in the water of the rocks, as carbonic acid gas in a soda water fountain exists in solution.

Mr Chance discusses some of the various ideas which have been hazarded concerning the origin, the place of origin, and the character of the gas in its underground reservoirs.

As to the origin of oil and gas, few conversant with the characteristics of oil and gas wells entertain the belief that the gas is being continuously manufactured in the rocks beneath the porous gas-sands, but the geologist cannot refute the possibility of this state of affairs on a small scale. There is no valid objection to the supposition that gas and oil have their origin in organic matter enclosed in the porous sandstones in which they are found; but whatever their origin be, experience has shown, in oil wells at least, that the porous rock reservoir holds a definitely limited quantity, and when this is once exhausted no further accumulation may be expected.

Briefly, the "Anticlinal Theory" is that the gas, existing in a gaseous form, might naturally be looked for in the anticlinal ridges traversing those localities of which some parts of the rocks form suitable reservoirs—in fact, that it rises as high as it can in the containing stratum. Did the gas exist in a liquid form this theory must go to the wall, because the difference in the specific gravity of the hydro-carbon liquid and of water could scarcely determine the course upwards of the former and downwards of the latter through miles of pores till the hydro-carbon reach the anticline, for it must be borne in mind that the inclination of these rocks is generally under one degree. Equally fatal to this theory would be the hypothesis of Prof. Lesley that the gas will exist in solution in the water of the rocks. Mr Chance argues, from established scientific facts, that the gas is neither liquefied nor held in solution. The pressures and temperatures required to liquefy the various gases contained in natural gas are known, and it is calculated that the pressure of superincumbent strata, immense as it is, must fall short of that required. There is good reason to believe that oil-producing districts lie in streaks, belts, and patches in a more or less continuous line, which may be either curved or straight; and this "belt line" theory was found useful in developing new wells, but was in many instances carried too far, till, through failure, belief in the theory was by many quondam believers discarded. To make use of these two theories together is advocated within limits which practice prescribes. Anticlines can be traced by surface observations, but the trend of the porous streaks or belts can only be defined by the records of wells already bored. It is evident that for the purpose of further development the "anticlinal theory" can only become useful after the configuration of the gas-producing belts or patches has been proved. J. H. R.

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MANCHESTER GEOLOGICAL SOCIETY. Vol. XVIII., Part 12.

ON WORKING COAL BY LONGWALL.

By W. E. GARFORTH, Mining Engineer.

The purport of this paper is not to compare the different systems of working, but to submit certain observations on Longwall, as applicable to deep mines. No system of working can produce the pressure due to the superincumbent strata, which becomes more apparent as the strata increase in thickness. In shallow workings pillars remain a long time undisturbed, whereas the deeper they go they get more crushed. In many cases down to a moderate depth, some seams are more profitably wrought by stoop and room; but, beyond a certain distance, the long-wall system is preferable, as coal can be extracted more economically and in better condition. In determining the method of working, it is not only the nature of the coal, but the character of the whole superincumbent and immediate over and under lying strata, which is to be considered. This paper is descriptive of the workings of a seam of coal, 3ft. 7in. thick, 420 yards from the surface, and is illustrated by plans showing the methods adopted in laying off the works. At first, stalls 30 yards wide were set out on end of the coal, having steps from 4 to 6 yards, in consequence of a number of slips being found at very irregular distances, running parallel to the bord of the coal. The coal after being holed required gunpowder to bring it down. This system was altered to half end and bord, which answered much better, the lines of face crossed the line of cleavage. The workings are ventilated by a furnace fed by 12,000 feet of fresh air producing 156,000 cubic feet of air per minute. The return current passes through a dumb drift to the upcast. At a distance beneath the main seam of from 4 to 16 feet there is a thin seam of inferior coal, which produces a good deal of gas, and from the superincumbent weight on the pack breaking the intervening strata, the gas was liberated into the upper seam but very irregularly. A method was adopted of putting down bore holes every 22 yards, thereby draining the gas gradually; at some points where the thin seam is within four feet of the main seam a small pit 4 feet diameter was sunk which prevented small fires which occasionally took place in the goaf where gas accumulated coming from the floor. The discussion which followed (as detailed in part 16) was confined to the bore holes,—their effect in liberating the gas from the under seam. In testing the pressure of gas from the bore holes, there was found to be no difference between those 4 feet deep and 16 feet deep.

J. S.

MANCHESTER GEOLOGICAL SOCIETY. Vol. XVIII., Part 13.

ACCIDENTS IN MINES AND THEIR PREVENTION.

By J. S. BURROWS, M.E.

This is the second part of a paper on the above subject, and treats on accidents underground other than by explosions. Taking the summary of the reports of the Government Inspectors for 1883, shaft accidents caused 97 deaths, miscellaneous accidents, tubs, &c., caused 246 deaths, falls of roofs and sides caused 469 deaths, making a total of 812, or six times the number of deaths (134) from explosions. Of the 97 deaths by shaft accidents 5 were from overwinding. The writer recommends detaching hooks as a means of safety. There were 7 deaths from the breaking of ropes. The method adopted by the writer is to fix a time at which the rope is to be taken off, no matter how good it may seem to be, dates are also fixed for re-capping, the first time at six months, the second at five, the third at four, the next at three, and afterwards every two months until the rope is taken off. By cutting off a few feet of the rope at each time of re-capping, the same part of the rope is not always on the pulley when decking the cages. There are 34 deaths from accidents whilst ascending and descending the shaft, 7 from falling down from the surface, 24 falling from mouthings in the shaft, 9 from material falling from the surface, 11 from miscellaneous causes, all of which could be prevented

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if proper care were taken to fence the mouth and openings in the shaft. There were 61 deaths from accidents on engine brows or jigs. A separate travelling road would obviate all these accidents, but in many cases this would entail very considerable expense. The deaths on account of accidents from trams and tubs are 102. The writer expects that ordinary foresight on the part of those immediately concerned should prevent most of these accidents. Explosions of gunpowder, &c., caused 34 deaths, another powerful argument against its use. The largest number of deaths (469) are caused by falls in the roof and sides, which seems reasonable to be expected when Nature's support—the coal—is removed. In treating this subject the systems of propping were compared. The writer considers there are as many accidents in the North country where the deputies set the timber, as in Lancashire where the setting is done by the colliers in their own places. Reasons are given for forming this opinion. From long familiarity with the dangers of coal mining, one cannot blame the men for possessing a large share of that physical courage, without which much of our mineral wealth would remain ungotten. Colliers have their living to make by piecework, and in pillar workings the roof is more or less on the move, and a place which might appear quite safe at one moment, may alter for the worse in a very short time. The discussion (at page 437, part 16) was very animated on the safety lamps generally used, and the danger of breaking the glasses of lamps like the Mueseler and the Marsaut. Different opinions were expressed regarding the timbering; as to whether it should be done by deputies appointed for the purpose, or by the miner keeping his own place secure. J. S.

MANCHESTER GEOLOGICAL SOCIETY, Vol. XXVIII., Part 14.

DESCRIPTION OF SCREENING ARRANGEMENTS AT BRINSOP HALL COLLIERIES,

By A. H. LEECH, M.E.

The great competition which now exists in the coal trade has necessitated a more careful handling and cleaning of coal. One of the most important duties of a colliery manager is to raise his coal and prepare it for the market in the best possible condition. To accomplish this, careful screening is required, as many seams contain irregular bands of dirt, black shale and brasses, which can only be taken out at the surface, and to enable this to be thoroughly done, many different methods of screening have been adopted. At Brinsop Hall Collieries, the screen in use has two sets of bars—one fixed and the other movable, arranged alternately. Both sets are fastened together at the bottom end by means of a rod which runs through a hole drilled at the end of each bar; at the upper end the stationary bars are bolted down to a fixed bar of iron. The movable bars are 4 inches longer than the fixed ones, and are also bolted on to a bar of iron; this bar is turned at each end, so as to admit of a roller 3 inches in diameter, which gives motion to the screen. The throw of the eccentrics is 8 inches, and the levers are so arranged as to give a stroke of about 2½ inches to the moving screen at its upper end, the moving bars make about 65 strokes per minute. The coal coming down the screens is landed on a movable belt made of steel wire, the mesh being 1¼in. by ½in., 4 feet wide and 16 feet between the centres of the drums. What slack is made on this belt passes into a shoot beneath. Here the cleaning of the coal is done, and the good portions are carried forward to the waggon. There was some difficulty and a good deal of labour in getting rid of the dirt taken out of the coal and separating it from the inferior coal. To overcome this difficulty a second belt was put up at each screen called a dirt belt. They were made of old flat wire rope, laid side by side, 15 inches in width, and 37 feet in length, which are also movable. The dirt and inferior coal is thrown by the screeners on to these dirt belts, where it is again sorted, the coal going to one shoot and the dirt to another, where trucks are placed to receive it. J. S.

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MANCHESTER GEOLOGICAL SOCIETY, Vol. XXVIII., Part 15.

ON ROCK SALT,

By THOMAS WARD.

Rock Salt is one of the most widely-spread minerals. There are but few countries in which it is not found; also, few geological formations from which it is absent, being evidence that the condition of things favourable to its formation existed at every period and at all places through geological ages, although during the Triassic period, circumstances more favourable to the production of salt beds of great thickness were more fully developed than at any other time. In inquiring into the origin of rock formations, it is well to understand the workings of nature in the past, and to ascertain if any similar deposit is going on now. The object of this paper is to prove that beds of rock salt have been crystallised out of the saturated water of salt lakes. Sea water, which contains on an average about 3½ per cent., is the great reservoir for salt, and from it many thousand tons of salt are extracted. In countries where the atmospheric heat is very powerful, salt is deposited on the shores of the seas, but with an overflowing tide or heavy rain it is soon dissolved, and under these circumstances no extensive deposit of salt can occur. Shallow basins are frequently prepared on the shore where the tide is allowed to flow. When full, all communication is shut off, and the water gradually evaporates, when the salt crystallizes. In this way salt is procured in many parts of the world. In illustrating the theory of the formation of rock salt, Mr Ward instances a great many places in different quarters of the globe where deposits are at present going on. Salt lakes are all formed in dry regions, where the amount of evaporation exceeds the rainfall, or at least equals it. These lakes have invariably streams or rivers running into them, but no streams flowing out. If the rainfall exceeds the evaporation, the water flowing into the lake would raise the level until it ran over and formed an overflow river or stream, and the water would become fresh. The great region of the salt lakes is in the neighbourhood of the Caspian Sea—the most remarkable is the Kara Boghaz. It is an enormous body of water, separated from the Caspian by a narrow channel about 150 yards wide and 5 feet deep. Owing to the enormous evaporation and the absence of streams running into the gulph, a current sets in from the Caspian with an average speed of three miles an hour. It has been variously estimated that the quantity of salt contained in the water passing daily is from 350,000 to 650,000 tons, which is forming a salt deposit of enormous extent. It invariably happens that salt forms upon mud, and during the rainy season a certain quantity of mud is deposited, and in the hot season evaporation takes place, and salt is deposited, the mud thus represents the wet season and the salt the dry. There is, however, this difference:—Mud is mixed mechanically with water and deposits as a sediment; whereas sea water forms a solution which rarely contains more than 3½ per cent. of salt, and before it would crystallize out, the whole body of water must contain at least 26 per cent. of salt, showing that salt can never be deposited from sea water in its ordinary state, and requires a large amount of evaporation. In support of this theory as to the formation of the rock salt beds of Cheshire, the climate must have been greatly different from what it is now, as it required a wet season and a dry one, and also a constantly varying elevation and depression of the earth's surface. It is, however, difficult to comprehend how, in a comparatively limited area such an enormous thickness of the beds of rock salt could be formed, as they are so differently deposited from the other sedimentary rocks, the matter forming such deposits being due to its heavier specific gravity, while rock salt requires so much evaporation before any deposit can be formed. In the discussion, the theory propounded by Mr Ward was generally approved of; but an expression of opinion was given by some members that the rock salt beds were not formed by the salt from the sea, but rather that the rock salt beds have given the salt to the sea. J. S.

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Transactions of the AMERICAN SOCIETY of CIVIL ENGINEERS, Vol. XIV.—May, 1885.

STRUCTURAL STEEL.

By EDWARD B. DORSEY.

The writer points out the rapid increase in the use of mild steel for structural purposes, especially in ship and bridge building. He quotes Mr Denny, shipbuilder, who says that "steel is comparatively uniform in quality, while with iron there is great deterioration and want of uniformity, and workmen complain if put to work iron on account of the amount of spoiled work it involves." Also, Mr Baker, engineer of the Forth Bridge, as follows—"When once you have got accustomed to steel, and the facility of working and welding it, you look upon iron as a poor sort of metal." Mr Dorsey concludes, "Engineers, especially those engaged in structural branches of the profession, should act upon the conclusion that in engineering the iron age is rapidly passing away, as the stone age has done, and will soon be replaced by the steel age."

ELECTRICAL TRANSMISSION FROM NIAGARA.

By BENJAMIN RHODES.

Quoting a remark commonly attributed to Sir William Thomson, that the power of Niagara could be utilized by transmitting it electrically to great distances, Mr Rhodes describes what has been done, and what may be done toward the utilization of Niagara for electrical purposes. He calculates the total power of the falls to be 7,000,000 H.P., of which there is at present nearly 1000 H.-P. utilized for various purposes, one of which is the lighting of Niagara village with electric light.

The Transactions of the Society for June, 1885, contain (I.) The Annual Address by the President, Frederick Graff, who reviewed some of the principal engineering works in course of construction, or finished during the past year. He notes the increasing number of cable roads for street traffic on the general plan originated in San Francisco in 1873, the cantiliver principle for railway bridges, such as the Forth Bridge, &c. Tunnelling under rivers and through mountains also comes under notice, those under the Mersey and Severn, and the Arlberg tunnel reaching from Innsbruck in the Tyrol to Lake Constance in Switzerland, receiving special mention. Canals, waterworks, and electricity were also noticed in this interesting address.

II.—Description of some EXPERIMENTS MADE ON the Providence, R.I., WATER WORKS to ascertain the force of WATER RAM IN PIPES,

By EDMUND B. WATSON.

This paper gives the results of experiments conducted by the writer, and is accompanied by numerous tables and diagrams.

Transactions of the AMERICAN INSTITUTE of MINING ENGINEERS—Feby., 1885.

I.—FUEL ECONOMY IN ENGINES AND BOILERS.

By P. BARNES, New York City.

The author draws attention to the loss sustained by the use of old and worn machinery, and gives reasons for recommending the use of high pressure steam with compound engines. In regard to boilers, he recommends the flat soled, or box form, with water tubes for heating surface.

In the discussion it was pointed out that pressures as high as 400lbs. per square inch were already being worked with, and the form of boiler designed by Mr Barnes was unfavourably criticised. J. Hg.

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Minutes of Proceedings of the INSTITUTION OF CIVIL ENGINEERS,
Vol. 84, 1885-1886, Part 2.

ON GAS PRODUCERS.

By F. J. ROWAN.

IN introducing this paper, Mr Rowan acknowledges that the large degree of favour in which the use of gaseous fuel is held among those connected with manufacturing operations, is principally due to the labours of the late Sir W. Siemens, and he predicts that, as the great advantage of this method of treating fuel becomes more widely known, it will be more extensively taken advantage of. The use of gaseous fuel has much to recommend it: it can be carried to the locality where it is to be used, and consumed without the accompaniment of either ash or cinder; it does not alter or affect the surfaces of the bodies destined to receive the heat, and the heat is discharged by radiation as well as by conduction, just where it is required. The actual condition of combustion, and the extent of the various losses in quantity of heat, occurring in coal-fired furnaces, have been formulated by Rankine, Minary, Galloway, and others, whose researches show that a higher calorific intensity may be obtained with gaseous fuel chiefly on account of the smaller quantity of air required for combustion, and, as a consequence, the much-lessened dilution of the heat by inert nitrogen and carbonic acid. Another advantage in the use of gaseous fuel is the important consideration of the value of the by-products which may be associated with its production: if any of the nitrogen existing in the coal is to be recovered as ammonia, the employment of a gas producer of some sort becomes a necessity. The author classifies and describes the different designs of the various gas producers, and gives a clear description of the course of progressive improvement, from the early experiments and crude apparatus of Faber du Faur and Bischof, to the recent and scientific producers of Siemens, Wilson, Gröbe and Lürmann, Sutherland, Young and Beilby, and others; and he states that the practical value of any of the examples of the various classes depends on the quality of the gas produced and the cost of production—a rough practical test of the efficiency of a gas producer being afforded by the percentage of carbonic acid and nitrogen contained in the gas, and the volume of gas of a given temperature per ton of coal. The paper is fully illustrated by a series of 68 wood-cuts.

ON THE INJURIOUS EFFECT OF A BLUE HEAT ON STEEL AND IRON.

By C. E. STROMEYER, C.E.

NOTWITHSTANDING the many excellent qualities possessed by mild steel, and the extraordinary favour into which it has recently come for use in shipbuilding and boilermaking, there are numerous instances in which steel plates and bars have failed in a most unaccountable manner. According to the theory advanced by Mr Stromeyer in this paper, there is every probability that the plates in question had been subjected to bending or hammering while hot, and he has little doubt that, while they were being so worked, these plates were at a blue heat, or, as smiths and boilermakers call it, a "black heat;" and it cannot be too widely known that such treatment is the most injurious to which steel can possibly be subjected. Iron possesses the same peculiarity, but as this material is very much less ductile than steel, similar failures are not so glaring, and, when they occur, are put down to bad quality. With the view of obtaining additional information on the influence of a blue heat on steel, the elaborate series of experiments detailed in this most important paper were undertaken by the author. The expression, "blue heat," is meant to include all those temperatures which produce discolouration of bright steel or iron surfaces, ranging from light straw to blue. The temperatures corresponding with the various colours are—

Straw colour, ...	470° Fah.
Dark straw, ...	480° Fah.
Violet, ...	490° Fah.
Blue, ...	500 to 600° Fah.

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The first question considered is, Has a blue heat the same influence on iron as on steel when being bent? The answer is decidedly, Yes. In proof of this, the lowest number of bends which ⅜ inch steel would stand at a blue heat was 2½, and Lowmoor iron of the same thickness, half a bend, whereas when cold the ⅜ inch steel would stand from 20 to 30 bends before breaking, and the Lowmoor iron about 3. In answer to the second question, Does bending permanently injure the ductility of steel and iron? the experiments show that steel which has been bent once or twice cold, will stand almost as many subsequent bends as the test pieces which had not been similarly treated; but, if the same material was bent once when blue hot, it lost almost all its ductility. Thin Lowmoor iron treated in the same way does not break quite so easily, but stands about one half the original number of bends, instead of breaking like glass or cast iron, as the steel under similar conditions would do.

All these results point unmistakably to the great danger which is incurred if iron or steel is worked at a blue heat. The difference between good iron and mild steel seems to be that iron breaks more easily than steel while being bent, when either hot or cold; that iron suffers more permanent injury than steel by cold working, but that if it has successfully withstood bending when hot, there is little probability of its flying to pieces when cold, as is almost sure to be the case with mild steel under simila treatment.

It is a very common practice among boilermakers to "take the chill out of a plate" if it requires a little setting, or to set a plate before it is cold. This is really nothing else than working it at a blue heat, and should never be allowed. All hammering or bending of iron or steel should be avoided unless the metals are either cold or red-hot. Where this is impossible, and where the plate or bar has not broken when blue-hot, it should be subsequently annealed.

The author remarks that it is satisfactory to learn that a practice has been gaining ground among boilermakers which should be encouraged. It consists in the cessation of work as soon as a plate which has been red-hot becomes so cool that the mark produced by rubbing a hammer handle or other piece of wood over it will not glow. A plate which is not hot enough to produce this effect, and yet too hot to be touched by hand, is most probably blue-hot, and should under no circumstances be hammered or bent. The same precautions ought to be observed in riveting. The rivet ought only to be hammered when it is red-hot; it should then be allowed to cool, and then "hardened up" when quite cold. The author has often noticed, in the case of ships that had been in collision, or in boilers requiring extensive repairs, where it was necessary to cut out many rivets, that three or four out of a dozen would always appear with a crystalline fracture. This, in his opinion, was due to the hammering of these particular rivets having been continued too long or recommenced too soon; in other words, work had been done on them when blue-hot, to the serious weakening of the structure in which they had been placed.

Mr Stromeyer exhibited a test piece which had been prepared in order to show the effect of working steel at a blue heat. It was ½ inch thick and two inches broad. One end was bent nearly double when cold; the other end was put between two pieces of red-hot iron, and, when blue-hot, was flattened under a steam hammer to about two-thirds of its original thickness. After the interval of a day, it broke with one blow of a hammer, and the fracture was perfectly crystalline. Another piece, but of smaller dimensions, had been prepared in the same way by being drawn out at a blue heat at one end, while the other end had been bent double when cold, showing the ductility of the metal. The piece was subsequently broken by striking it on an anvil, and it was seen that it had fractured at a point where the heat had not exceeded a straw colour.

Whatever be the cause of the peculiarity, and whether it will ever be possible to produce steel and iron which will not be blue-short, it is at least clear that the experiments described in this paper show how steel can with certainty be made permanently brittle. In practice, everything should therefore be done to avoid any treatment at all involving the working of iron or steel while blue-hot. J. P.

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Transactions of the AMERICAN INSTITUTE OF MINING ENGINEERS.—Feby., 1886.

II.—THE SOURCE AND BEHAVIOUR OF FIRE-GAS IN THE JOHNSTOWN MINES.

By JOHN FULTON, Johnstown.

Mr Fulton gives a description of the mines, and a short account of the few explosions which have occurred in them. He comes to the conclusion that the gas found in the mines has its source in the porous sandstone under the coal measures. This was supported in the discussion.

CLEVELAND INSTITUTION of ENGINEERS' Proceedings, April 13, 1885.

TELPHER LINES; or, The Transport of Goods on Ariel Tramways, with the Aid of Electricity.

By PROFESSOR FLEEMING JENKIN, LL.D., F.R.S.

The name "Telpherage" has been given to a system of automatically transporting goods by electrical means, and this paper gives an account of a telpher line in use at Glynde, in Sussex.

There are two lines of way, an up and a down line, supported on crossheads of posts, consisting of ¾in. round steel. These are maintained at different potentials by the dynamo stationed at the centre of the line, which is less than one mile in length. The electric current flowing round a motor drives a shaft at the rate of 1600 revolutions per minute. This shaft is connected by suitable gearing to the driving wheels of the locomotive, which hauls along the train at a speed of about four miles per hour. The locomotives weigh about 3 cwt. Each train will convey one ton net load in ten trucks; the weight of each truck is about 55lbs. The tension on the line is regulated by straining posts, of which there are four to the mile. This arrangement gives compensation for changes of temperature. The total weight of steel in the two lines is 10½ tons, and the weight of cast-iron in the saddles is 11 tons per mile for the double line. To give grip on the steel rods, the locomotive is tyred with india-rubber. The line is of varying gradients and the locomotives are regularlated by specially designed governors. The paper is illustrated by diagrams and woodcuts. J. HG.

Transactions of the AMERICAN INSTITUTE OF MINING ENGINEERS.—Feby., 1886.

THE GEOLOGY OF THE PITTSBURGH COAL-REGION.

By J. P. LESLEY, State Geologist of Pennsylvania.

The paper opens with a panegyric on "perhaps, the most valuable spot on the surface of the planet." This coal region teems with a population engaged in industrial enterprises of innumerable forms, and is well supplied with navigable rivers. Great Mammon might be pictured sitting here gloating over the untold wealth, not of

> "Great heaps of gold that never could be spent,
> But of coal, great source of Mulciber's devouring element,"

to which might be added oil and gas, and iron ore. The extraordinary wealth of the region is due to the coal deposits, and not to the evanescent, though meanwhile valuable, supplies of petroleum and natural gas. Speaking of the comparatively limited store of oil and gas, Prof. Lesley says "our children will merely, and with difficulty, drain the dregs." To this a very antithesis is presented in the case of coal. The coal measures of the Pittsburg region are about 2000 feet thick, and contain at least fifteen workable seams, fairly persistent and recognisable, estimated capable of yielding 30,000 million tons of coal, of which the Pittsburgh bed will yield one-third. Mr L.

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puts forward the speculation that this coalfield had at one time a quasi-continental outspread: and if that view be correct, Pennsylvania State only possesses 1 per cent. of its original quantity of coal.

The value of the Pittsburg coal depends on—1, its superior quality; 2, its unlimited quantity within easy reach; 3, the exceptionally favourable geological structure of the region; but not upon the size of the individual coal-beds. The beds range from 4 to 12 and even 15 feet in thickness; and at present nearly all the mines of the region are drained naturally into the open river valleys; and the general slope is perhaps some 20 ft. per mile. But what a forcible contrast these facts, as stated by Mr *L.*, form to the features of the Belgian coalfield, where around Mons, there are known to be from 130 to 160 seams, of which two-thirds are workable, and the average thickness of the seams actually worked in Belgium is 2 feet. Add to these features the extraordinary plications of the strata and the now serious depth of many of the pits, and a picture is completed standing as a foil to the scarcely rivalled perfection of the Pittsburgh region. The sinking of deep shafts is here relegated to the pleasantly distant future. It is impossible to review even briefly the account of the geological details which are marshalled in a lucid way, though to an old world reader many of the names introduced wear a strange aspect—possibly old friends in Indian costume. J. H. R.

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PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS,
Volume 85. 1885-86. Part 3.

ON THE EXPLOSION OF HOMOGENEOUS GASEOUS MIXTURES,

By DUGALD CLERK, F.C.S.

THE experiments described in this paper were made by Mr Clerk with the view of obtaining accurate data for the thorough understanding of the gas-engine, and also if possible, to find the reason why the observed pressure produced by the explosion of gaseous mixtures, falls so much short of the theoretical pressure. Thus, in some experiments made by Hirn in 1861, a mixture of 1 volume of hydrogen with 9 volumes of air which should by calculation have given a maximum pressure of 5·8 atmospheres, gave only 3·25, and a similar deficiency was observed when mixtures of coal-gas were used. Bunsen, in 1866, made a more extended set of experiments, using a very small explosion vessel, and passing the igniting spark through the whole length of the column, to make certain of the instantaneous spread of the flame. His experiments supported those of Hirn, a precisely similar difference between the calculated and the observed pressures being proved. More recently Messrs Mallard and Le Chatelier and Messrs Berthold and Vieille, have made numerous experiments and have also arrived at similar conclusions—all agreeing upon the fact of the deficit, but differing in their method of explaining it. Hirn supposes the limiting cause to be the cooling effect of the walls of the enclosing vessel, Bunsen the approach of the ignited gases to the dissociating point of the compounds formed by the combustion, and Mallard and Le Chatelier to an enormous increase of the specific heat of oxygen, nitrogen, and the products of combustion as the temperature approaches 1000 to 2000 C.

The following is a description of the explosion vessel used by the author in his experiments. It is a strong cast-iron cylinder, the internal space being 7 inches in diameter and 8½ inches long, closed completely by covers on top and bottom, firmly bolted and so arranged as to be easily and quickly separated for cleaning the walls. On the upper cover is mounted a Richards indicator, from which the ordinary reciprocating drum has been removed and a revolving one substituted, driven by a clockwork arrangement, and suitable for taking diagrams. A pair of insulated points project inwards through a plug in the bottom cover, which serve to ignite the mixture. In making the experiments, the explosion vessel, before being charged, was exhausted by an air-pump, and every precaution was taken to secure accuracy so that the diagrams obtained could be relied on to give an exact record of the rapidity, intensity, and duration of the explosions to which they refer. The following Table has been calculated from the diagrams, giving the maximum pressures and temperatures as well as the fraction of a second elapsing between the beginning of the increase of pressure and the attainment of the maximum pressure—being the time of explosion—in different mixtures of coal gas and air.

GLASGOW COAL-GAS AND AIR MIXTURES.

Temperature of Gases before ignition 18° C. Pressure atmospheric (14·7 lbs.)

Experiment.	Proportion of Gas by Volume.	Maximum Pressure.	Maximum Temperature Centigrade.	Time of explosion second.
a	1-14th	52 lbs. per sq. inch above atm.	1,047	0·28
b	1-12th	68 ,, ,, ,,	1,265	0·18
c	1-10th	69 ,, ,, ,,	1,384	0·13
d	1-8th	89 ,, ,, ,,	1,780	0·07
e	1-6th	96 ,, ,, ,,	1,918	0·05

From these experiments it is seen that the greatest possible pressure exerted by the explosion of a mixture of Glasgow gas and air, is 96 lbs. per square inch; the maximum pressure is reduced as the proportion of gas in the mixture diminishes, and the time of explosion increases the more the mixture is diluted. With a mixture containing 1-14th of its volume of coal gas, the time of explosion is ¼ of a second, with 1-6th of coal gas

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the time is reduced to 1-20th of a second. With the mixture a, a very large excess of oxygen is present, in mixture e less oxygen is present than is required to completely burn the gas.

Many similar experiments were made with Oldham gas, and the following nine have been calculated from the diagrammatic curves produced.

OLDHAM COAL GAS AND AIR MIXTURES.

Temperature of Gases before ignition 17° C. Pressure atmospheric (14·7 lbs.)

Experiment.	Proportion of Gas by Volume.	Maximum Pressure.	Maximum Temperature Centigrade.	Time of explosion second.
a	1-15th	40 lbs. per sq. inch above atm.	806	0·45
b	1-14th	51·5 ,, ,, ,,	1,033	0·31
c	1-13th	60·0 ,, ,, ,,	1,202	0·24
d	1-12th	61·0 ,, ,, ,,	1,220	0·17
e	1-10th	78·0 ,, ,, ,,	1,557	0·08
f	1-8th	87·0 ,, ,, ,,	1,733	0·06
g	1-7th	90·0 ,, ,, ,,	1,792	0·04
h	1-6th	91·0 ,, ,, ,,	1,812	0·055
i	1-5th	80·0 ,, ,, ,,	1,595	0·16

The greatest pressure produced by the explosion of a mixture of this gas and air was in experiment h. 91 lbs. per square inch—there was present in this case a little more gas than there was oxygen to burn it. The mixture a, 1 volume gas 14 volumes air is the most dilute which can be ignited by the electric spark at ordinary atmospheric temperature. A mixture of 1 volume of gas and 15 volumes of air failed to ignite although it was repeatedly tried.

Comparing Glasgow and Oldham gas they are very nearly equal in capacity to produce power in a gas engine, equal volumes of the gases developing nearly equal power. The Glasgow gas, however, gives a more sustained pressure in 0·2 second after the maximum pressure—75 per cent. of the pressure still remaining as against 70 per cent with the Oldham gas. The Glasgow gas will therefore give a greater power for a given consumption than Oldham gas. Some experiments were also made with hydrogen but it was found that this gas was not at all suitable for developing power—the difference being so great that an engine capable of indicating 10 horse power when using Glasgow or Oldham gas would not indicate more than 3·7 horse power using hydrogen gas. The luminosity of Glasgow gas is equal to 20 candles, and Oldham gas to 16 candles.

In the author's opinion, no single cause explains the limit and other phenomena of gaseous explosions, and while agreeing that the theories of Hirn, Bunsen, and Mallard and Le Chatelier, have each a certain weight, the conclusions he arrives at as the result of his experiments are, that combustion is very similar to other chemical actions, the first part of the reaction occurring rapidly and proceeding with increasing difficulty as the combustion approaches completion, and that it may cause evolution of heat at rates greater than, equal to, or less than, the rate of cooling, and that the limiting causes act after the flame has spread completely throughout the explosion vessel. Appended to the paper is a plate showing the indicator diagrams, from which the above tables have been calculated. J. P.

BLASTING OPERATIONS at HELL GATE, NEW YORK.

By L. F. VERNON HARCOURT, M.A., M. Inst. C E.

Works for the improvement of the channel giving access to New York harbour were begun in 1848, but at that time the cost of removing submerged rocks was so great that little more than the lowering of the most dangerous peaks was then attempted. In 1867

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General Newton reported in favour of a comprehensive scheme of improvement by the removal of Hallett's Point, Middle Reef, &c., to a depth of 26 feet at mean low water. As the ordinary methods of surface blasting which were first tried for this purpose, were found to involve a very large expenditure in proportion to the results obtained, the plan was adopted of sinking a shaft on Hallett's Point, driving a network of galleries throughout the area of 3 acres within the 26 feet contour, and finally shattering both roof and pillars by a simultaneous explosion, the *debris* of rock being subsequently removed by grapple dredgers down to the requisite depth. The progress of the work was slow, but it was completed in March, 1876. The preparing for and placing the charges were next proceeded with, and 50,000lbs. of explosives having been lodged in the roof and pillars, the galleries and shaft were flooded on September 23rd, 1876, and the explosion was effected on the 24th. Spray, mingled with vapour and gases, rose 128 feet at the highest point, but no damage was done, and the land tremor was slight. Altogether, 63,135 cubic yards of solid rock was shattered by this explosion at a cost, including removal, of £250,420.

The success of the system adopted at Hallett's Point being fully assured, General Newton urged the commencement of a similar work for lowering the Middle Reef, which covered an area of 9 acres above the 26 foot contour. Work was commenced in June, 1875, by sinking two shafts, 65 feet apart, the larger shaft being 20 feet by 10 feet, and 60 feet deep below low water, the smaller shaft being 12 feet square. A series of parallel galleries were driven with other galleries at right angles, under the whole area to be lowered. Altogether, the length of the galleries excavated was 21,669 feet, they averaged 10 feet by 10 feet in section, but varied in places from 4 to 33 feet in height, the roof averaging 18·8 feet in thickness, was supported by 467 pillars about 15 feet square, and 25 feet apart. The amount of rock excavated in forming the galleries was 80,232 cubic yards, requiring 2·31lbs. of explosives, and 11·97 feet of drilling for each cubic yard, and the contents of the roof and pillars to be shattered amounted to 270,717 cubic yards.

The progress of the work was slow, owing to financial restrictions and the inrush of large quantities of water through seams in the roof, one fissure met with was 10 inches wide and 100 feet long, another from 1 to 4 inches wide, extended right across the reef, over 400 feet in length. These fissures were filled up with Portland cement as they were opened out. The drilling of the holes for the final explosion was commenced in May, 1882: the holes had a diameter of about 3 inches, and averaged 9 feet in depth, 772 holes were drilled in the pillars, and 11,789 holes in the roof, being placed about 5 feet apart in the pillars, and 4 feet in the roof, at angles respectively of 45 degrees and 60 degrees.

The charging of the holes was commenced at the end of July, 1885. Rackarock, composed of 79 parts of potassium chlorate, and 21 parts of nitrobenzol, was used instead of dynamite for the bulk of the cartridges, as its ingredients being harmless previous to their admixture, could be stored in large quantities and conveyed without danger to where the mixing was done. The great value of this kind of explosive, composed of a solid and a liquid, consists in the facility and safety with which the mixture of the ingredients is effected by the simple absorption of the liquid by the solid, whereas two, solids, equally harmless apart, could not be thoroughly mixed on the spot in large quantities to form a similar explosive, without extraordinary risk. In charging, each hole was nearly filled with rackarock cartridges, then a 3lb. dynamite cartridge was last inserted, having a 30 grain fulminate exploder, in its outer end which projected about 6 inches out of the hole, and the whole charge, which consisted of 240,399lbs. of rackarock, and 42,331 lbs. of dynamite, was exploded by sympathy, being unconnected with the batteries used for firing the mine. The primary explosion was effected by 591 10lb. dynamite exploders placed along the galleries at intervals of 25 feet, as it had been proved by experiment that a 10lb. charge of dynamite would discharge with certainty under water, another charge of dynamite in a thin elastic case at a distance of 27 feet. The exploders were arranged in 21 circuits of 25 each, and 3 circuits of 22 each, and adjacent exploders were placed on different circuits, so that they might explode by sympathy if any of the

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circuits failed. The flooding of the galleries was commenced by two syphons on October 9th, and the explosion was successfully effected at 11.13 a.m. on October 16th, 1885. No loud report or great shock occurred, but the water rose in a mass over the site of the reef, the spray shooting up in peaks at some points between 100 and 200 feet high.

The total estimated cost of the Hell Gate Improvement Works amounts to £1,070,650, and when fully completed, by the removal of the *debris* on the Middle Reef, will afford New York an excellent direct channel to the ocean through Long Island Sound. J. P.

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THE

MINING INSTITUTE

OF

SCOTLAND.

LIST OF MEMBERS,

1886-87.

THE RULES REMAIN AS REVISED AT THE ANNUAL MEETING, 12th APRIL, 1883.

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The Mining Institute of Scotland.

1886-87.

HONORARY MEMBERS.

	Year of Entry.
MOORE, RALPH, H.M. Inspector of Mines, 13 Clairmont Gardens, Glasgow *(Past President)*, - -	1878
ROBSON, JOSEPH T., H.M. Inspector of Mines, Swansea *(Vice-President)*, - - - - -	1878
RONALDSON, JOHN M., H.M. Inspector of Mines, Belton Villa, Pollokshields *(Vice-President)*, - -	1879

ORDINARY MEMBERS.

Subscription £1 1s.

Adams, James, Hill of Beath, Fife, - - -	1880
Aitken, Henry, Darroch, Falkirk, - - - -	1878
Anderson, David, Bothwell Road, Hamilton *(Vice-President)*, - - - - - -	1879
Anderson, George, Ashton Villa, Plains, Airdrie, - -	1880
Anderson, James, Farme Colliery, Rutherglen, - -	1880
Angus, John, Muirkirk Iron Works, Muirkirk, - -	1884
Annandale, Earnest V., Bielside, Dunbar, - - -	1886

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Arrol, Arthur T., Germiston Iron Works, Petershill Road, Glasgow, - - - - - - 1879

Austine, John, Oak Lodge, Hamilton *(Past Vice-President)*, 1878

Baird, Archibald, Park Road, Hamilton, - - - 1879

Baird, Matthew B., Charleville, Uddingston, - - 1880

Baird, Robert, 141 St. Vincent Street, Glasgow, - - 1879

Barr, James, Longlee Colliery, Larkhall, - - - 1879

Barr, William, Over-Dalserf Colliery, Larkhall, - - 1879

Barrowman, James, South Park Road, Hamilton *(Secretary)* 1879

Begg, Gilbert Burns, Brandon Street, Motherwell *(Past President)*, - - - - - - 1878

Beilby, George, St. Kitts, Slateford, - - - 1884

Bell, George F., 2 Belmont Crescent, Glasgow, - - 1886

Bell, James, San Fermin Mining Company, Portugalete, Bilbao, - - - - - - 1881

Birrel, George, Dunfermline, - - - - 1880

Bishop, George A., Royal Bank, Coatbridge, - 1879

Blackadder, Alexander, Stand Colliery, Airdrie, - - 1880

Borland, Thomas, Clyde Iron Works, Tollcross, Glasgow, - 1880

Brand, A. Douglas, 6 Dixon Street, Glasgow, - - 1881

Brown, Thomas M., Lanemark Colliery, New Cumnock, - 1880

Buchanan, D. C. R. C., Drumpellier, Coatbridge, - - 1881

Calderwood, Robert, Oakbank Shale Works, Mid Calder, - 1880

Cameron, Robert, Priory Lodge, Blantyre, - - 1879

Cameron, William J., Finnie Street, Kilmarnock, - - 1885

Campbell, Archibald, Redding Collieries, Polmont Station, 1883

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Carlow, Charles, The Fife Coal Company, Leven, - - 1879
Clark, James, Ormiston Station Colliery, Ormiston, - 1880
Clark, Robert, Arniston Colliery, Gorebridge, - - 1883
Colquhoun, James, Tredegar Iron Works, South Wales, - 1882
Connal, John, 123 St. Vincent Street, Glasgow, - - 1882
Cook, William, Jun., Elliot Street, Glasgow, - - 1885
Cowan, David, Carron Iron Works, Falkirk *(Councillor)*, - 1879
Coats, William A., Ferguslie House, Paisley, - - 1834
Cuninghame, Alex., Carnbroe Iron Works, Coatbridge, - 1880
Cuninghame, J. C., 127 St. Vincent Street, Glasgow, - 1879
Cuninghame, John, 127 St. Vincent Street, Glasgow, - 1879
Curry, William T., Usworth Hall, Washington Stn., R.S.D. Co., Durham, - - - - 1883

Dalzell, John B., Portland Park, Hamilton, - - 1881
Darling, John, Cleugh Gas Coal Works, Forth, Lanark, - 1880
Denniston, R. B., 79 Princes Street, Dunedin, N.Z., - 1886
Dick, Alexander, Denby Colliery, Derby, - - - 1884
Dixon, James S., Bent Colliery, Hamilton *(President)*, - 1879
Dougall, George, Bonnymuir Works, Bonnybridge, - 1884
Duff, William, 79 Finnieston Street, Glasgow, - - 1886
Dunlop, Colin, Jun., Quarter Iron Works, Hamilton, - 1884
Dunn, David G., 11 Knowe Terrace, Pollokshields, - 1882
Dunn, Hugh S., Earlston Villa, Caprington, Kilmarnock, - 1885
Dunn, John, Bothwell, - - - - 1881
Durie, John, Elphingstone Colliery, Tranent, - - 1880

Ferguson, Peter, 68 Anderston Quay, Glasgow, - - 1885

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Forrest, John Clark, Hamilton, - - - - 1885
Frew, Robert, 75 Bath Street, Glasgow, - - - 1879

Galloway, John, Ardrossan, - - - - 1879
Galloway, Robert L., 98 West George Street, Glasgow, *(Councillor)*, - - - - - 1884
Galloway, T. Lindsay, Argyll Colliery, Campbeltown, - 1880
Gardiner, David, Meiklehill Colliery, Kirkintilloch, - 1881
Geddes, G. H., 142 Princes Street, Edinburgh, - - 1881
Gemmell, John, 96 New City Road, Glasgow, - - 1883
Gilmour, Allan, Portland Colliery, Kilmarnock, - - 1879
Glen, Robert, Eastfield Colliery, Cambuslang, - - 1881
Grant, A. M., Townholm Engine Works, Kilmarnock, *(Councillor)*, - - - - - 1884
Grant, T. M., Clyde Locomotive Works, Springburn, Glasgow, - - - - - - 1879
Gray, Archibald, Middleton House, Dalry, Ayrshire, - 1883
Gray, Archibald, Keyshill, Dalry, - - - 1881
Gray, John, Avon Cottage, Stonehouse, - - - 1882
Grierson, Thomas, Glebe Colliery, Douglas, - - 1881
Griffiths, A., Bonnybridge, Denny, - - - 1887

Hamilton, Lord, of Dalzell, Motherwell, - - - 1881
Hamilton, Thomas, 101 West Regent Street, Glasgow, - 1879
Henderson, Norman M., Broxburn Oil Works, Broxburn, 1884
Hill, Alexander, Mina de Tinoca, Campo Maier, Portugal, 1883
Hill, Laurence, 5 Doune Gardens, Glasgow, - - 1883
Hodson, James, Liverpool Road, St. Helens, Lancashire, - 1880

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Hogg, John, Victoria Engine Works, Airdrie, - - 1884
Hood, Archibald, 6 Bute Crescent, Cardiff, - - 1879
Hossack, W. B., Dunmore Cottage, Airdrie, - - 1885
Hurll, Mark, Woodneuk, Gartcosh, - - - 1880
Hutchison, Joseph, Woodside Colliery, Dalserf, - - 1881
Hyslop, Jonathan, The Cottage, Airdriehouse, Airdrie, - 1881

Irvine, C. Maclaren, Fence Colliery, Blackwood, Lesmahagow, 1880

Jack, Robert, Bank of Scotland, Motherwell, - - 1883
Jamieson, James Auldjo, 66 Queen Street, Edinburgh, - 1885
Jenkins, James G., 33 Renfield Street, Glasgow, - - 1882
Johnston, David, 12 York Street, Glasgow, - - 1881
Johnstone, Ronald H., 75 West Nile Street, Glasgow, - 1879

Keith, Daniel, Arden Lime Works, Barrhead, - - 1883
Kesson, Andrew, Bothwell, - - - - 1885
* Kirkpatrick, Alexander, Allanshaw, Hamilton, - - 1884

Landale, David, The Binn, Burntisland, - - - 1883
Lewin, Henry W., Drumpellier, Coatbridge, - - 1882

M'Creath, George W., 95 Bath Street, Glasgow, - - 1879
M'Creath, James, 95 Bath Street, Glasgow (*Past President*), 1879
M'Culloch, David, Vulcan Works, Kilmarnock, - - 1885
M'Culloch, John, Monkland Iron and Coal Works, Airdrie, 1879
M'Culloch, Thomas, Vulcan Works, Kilmarnock, - - 1885

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* Deceased.

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Macdonald, Symington, The Great Kanawha Colliery Co. (Limited), Mount Carbon, West Virginia, U.S.A., - 1880
Mackay, Andrew, Grangemouth Coal Co., Grangemouth, - 1879
M'Kenzie, Kenneth, New Bank Colliery, New Cumnock, - 1880
M'Kenzie, William, Newbattle Collieries, Dalkeith, - 1880
M'Killop, James, Slamannan, - - - - 1886
M'Kinnell, William, Clyde Steel and Iron Works, Sheffield, 1887
M'Laren, Robert, Dunbeth Terrace, Coatbridge, - - 1882
M'Laren, William, Orchards, Bellshill, - - - 1884
M'Lauchlan, J. D., 35 South Bruntsfield Place, Edinburgh, 1882
M'Lean, Andrew, Hill Colliery, Netherburn, by Hamilton, 1880
M'Nab, John, Flemington Coal Co. (Limited), Cambuslang, 1881
M'Naughton, James, 11 West Regent Street, Glasgow, - 1880

Marshall, R. A., 170 Hope Street, Glasgow, - - 1879
Miller, Thomas H., Vulcan Foundry, Coatbridge, - - 1885
Mitchell, George A., 67 West Nile Street, Glasgow, - 1881
Moffat Peter, 14 Ure Place, Montrose Street, Glasgow, - 1881
Moore, Robert T., 134 St. Vincent Street, Glasgow, - 1880
Morrison, David G., Britannia Works, Kilmarnock, - 1885
Morison, John, Newbattle Collieries, Dalkeith, - - 1879
Morton, James, Manor Park, Blairhill, Coatbridge, - 1880
Mungall, Henry, Cowdenbeath Collieries, Cowdenbeath, - 1880
Munro, R. D., 141 Buchanan Street, Glasgow, - - 1883
Murdoch Alexander, 11 West Regent Street, Glasgow, - 1886

Nasmyth, A. H., Donibristle Colliery, Crossgates, Fife, - 1880
Nasmyth, J. A., Donibristle Colliery, Crossgates, Fife, - 1883

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Neilson, George, Summerlee Iron Works, Coatbridge, - 1880
Neilson, John, Summerlee Iron Works, Coatbridge, - 1883
Nimmo, John, 85 Clerk Street, Edinburgh, - - 1885

Ormiston, A. R., Gartness Coal Coy., 19 Waterloo Street, Glasgow, - - - - - - 1880
Ormiston, James, Mount Vernon, Glasgow, - - 1880

Park, John, Stonelaw Colliery, Rutherglen, - - 1881
Paterson, A. G., Earl of Rosslyn's Collieries, Dysart, - 1886
Paul, James, 7 Shandwick Place, Edinburgh, - - 1879
Pickering, John, 54 West Regent Street, Glasgow, - 1883
Pratt, George, 29 Waterloo Street, Glasgow, - - 1879

Rankin, John, jun., Drumgray Colliery, Airdrie, - - 1881
Rankine, David, 75 West Nile Street, Glasgow, - - 1879
Reid, John, Loanhead House, Baillieston, - - - 1881
Reid, John, 74 Bath Street, Glasgow, - - - 1883
Robertson, David, 21 Pitt Street, Glasgow, - - 1880
Robertson, D. A. W., South Russell Street, Grahamston, Falkirk, - - - - - - 1882
Robertson, Dr. J. R. M., South Russell Street, Grahamston, Falkirk, - - - - - - 1886
Robertson, William, 123 St. Vincent Street, Glasgow, - 1879
Rowan, Fred. J., 134 St. Vincent Street, Glasgow, - 1883
Roxburgh, Alexander, Alloa Coal Co., Alloa, - - 1880
Roy, William, Limerig and West Drumclair Collieries, Slamannan, - - - - - 1879

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Russell, Archibald, jun., Roslin, Bothwell, - - 1882
Russell, George, Summerlee Iron Works, Coatbridge, - 1883
Russell, Robert, Coltness Iron Works, Newmains, - 1878

Sharp, Robert, Coatbridge, - - - - 1886
Smart, James, Balgreen, Hamilton (*Vice-President*), - 1879
Smith, jun., Eustace, St. Lawrence Ropery, Newcastle-on-Tyne, - - - - - - 1885
Smith, George W., Port Elizabeth, South Africa, - - 1883
Smith, James, Saracen Colliery, Possil, - - - 1884
Speirs, Alexander, jun., 28 St. Enoch Square, Glasgow, - 1879
Spowart, Thomas, Broomhead, Dunfermline, - - 1881
Stafford, Thomas W., 157 West George Street, Glasgow, - 1885
Stevenson, Hugh, 21 Clyde Place, Glasgow, - - 1884
Stewart, Alex., Tharsis Mines, Huelva, Spain, - - 1879
Stewart, Robert, 1 Dixon Street, Glasgow, - - 1883
Struthers, William, 75 West Nile Street, Glasgow, - 1885
Sutherland, Donald, 27 Stanley Street, Glasgow, - - 1885
Sutherland, Henry, 65 West Regent Street, Glasgow, - 1884

Terris, Henry, Clackmannan Colliery, Clackmannan, - 1880
Thomson, Alex., 112 Bath Street, Glasgow, - - 1880
Thomson, Charles, Calder Ironworks, Coatbridge, - 1879
Thomson, Robert D., Jerviston House, Motherwell, - 1883
* Thomson, Samuel, Jerviston House, Motherwell, - 1879
Thomson, Thomas, Monastery Street, Dunfermline, - 1884
Thornton, Peter, Crofthead, Fauldhouse, - - - 1878
Thornton, Thomas, Auchinheath Colliery, Lesmahagow, - 1879

* Deceased.

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Topping, R. M., Blantyre Foundry, Blantyre, - - 1879
Torrance, James W., 81 St. Vincent Street, Glasgow, - 1881
Tweedie, James A., Carron Works, Falkirk, - - 1887

Waldie, James, 103 Leith Walk, Leith, - - - 1882
Waldie, James F., 21 Hope Street, Glasgow, - - 1883
Walker, James, 66 Waterloo Street, Glasgow, - - 1883
Walker, James P., Dalmellington Iron Works, Ayrshire, - 1880
Walker, William H., - - - - - 1880
Wallace, James, Wester Gartshore Colliery, Kirkintilloch, 1882
Watson, John, Earnock, Hamilton, - - - 1879
Watson, William, Bank Street, Coatbridge, - - 1886
Weir, Alexander, Murieston, Mount Vernon, - - 1881
Weir, Thomas D., 97 West Regent Street, Glasgow, - 1884
Whitelaw, Thomas, Dalzell Colliery, Motherwell, - - 1879
Whyte, Robert, Royal Exchange, Glasgow, - - 1887
Williams, John, jun., Excelsior Iron Works, Wishaw, - 1884
Williamson, John R., 12 St. Andrew Square, Edinburgh, 1882
Wilson, Andrew, Dalzell Estate Office, Motherwell, - 1880
Wilson, Andrew M., 41 Pitt Street, Glasgow, - - 1880
Wilson, John, Alderston, Mid-Calder, - - - 1881
Wilson, John, Dechmont Lodge, Bothwell, - - 1879
Wilson, William, Lochhead Works, Dunfermline, - - 1883
Wood, James, 40 St. Enoch Square, Glasgow, - - 1880
Wylie, John, Clifton Iron Works, Coatbridge, - - 1883

Young, John, Baljaffray Colliery, New Kilpatrick, - 1881
Young, Robert, 37 West George Street, Glasgow, - - 1882
Young, William, 204 Stobcross Street, Glasgow, - - 1885

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ORDINARY MEMBERS.

Subscription, 10s 6d.

Allan, John, Calder Iron Works, Coatbridge, - - 1881
Allan, William, Woodyett and Dennymill Mines, Denny, - 1881
Allardice, James, Eastfield Colliery, Cambuslang, - - 1881
Anderson, David, Cowdenbeath Colliery, Cowdenbeath, - 1881
Anderson, George, Barkip Colliery, Dalry, - - 1880
Anderson, George, Ferniegair Colliery, Hamilton, - - 1885
Anderson, John, Lochgelly Iron and Coal Coy., Lochgelly, 1880
Andrew, Robert, Minas de Aznalcóllar, Seville, Spain, - 1880
Andrew, William, Lassodie Colliery, Dunfermline, - 1880
Angus, George S., Albyn Cottages, Broxburn, - - 1884
Archibald, William, Haywood Colliery, Lanark, - - 1879
Arnott, Thomas, Summerlee Iron Works, Coatbridge, *(Councillor)*, . - - - - 1879

Baird, Dugald, Raith Colliery, Cowdenbeath, - - 1887
Baxter, Robert, East Benhar Colliery, Fauldhouse, - 1880
Begg, John, Whitehill Colliery, Rosewell, - - - 1879
Beith, Andrew, 28 Regent Street, Portobello, - - 1885
Beith, Robert, Townlands Colliery, Hamilton *(Councillor)*, 1878
Beveridge, James, Linlithgow Oil Coy., Linlithgow, - 1882
Beveridge, John, Kelty Colliery Blairadam, - - 1881
Blyth, Archibald, Bent Colliery, Hamilton *(Treasurer)*, - 1878
Borrowman, James, Hilltop Colliery, Longton, - - 1881

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Bowie, Hunter, Lugar Iron Works, Old Cumnock, - 1881
Bowser, C. H., 13 Royal Crescent, Glasgow, - - 1885
Brown, George, Longriggend Colliery, Airdrie, - - 1880
Brown, Robert, Bellfield Colliery, Hurlford, Kilmarnock, - 1883
Brown, Robert C., - - - - - 1885
Brown, Peter, Martin's Crescent, Airdrie, - - - 1881
Brown, William, Newton Colliery, Newton, - - 1883
Brownlie, Archibald, Lassodie Colliery, Dunfermline, - 1883
Bryden, David, Coylton, Ayr, - - - - 1881
Burt, Hutchison, Fordell Colliery, Crossgates, Fifeshire, - 1885

Campbell, Alexander, Burgh Colliery, Irvine, - - 1882
Campbell, Thomas, Spindleside Colliery, Omoa, Motherwell, - - - - - - 1881
Campbell, William, - - - - - 1883
Carey, William, Grange Colliery, Bo'ness, - - 1882
Carmichael, Robert, Earnock Colliery, Hamilton, - - 1880
Clarke, J. A., Ayr Colliery, Ayr, - - - - 1880
Clark, William, 95 Bath Street, Glasgow, - - - 1883
Clelland, James, Carronhall Colliery, Falkirk, - - 1879
Cochrane, Joseph, Newton Colliery, Newton, - - 1883
Cochrane, Neil, - - - - - - 1881
Colquhoun, Robert, - - - - - 1882
Cowan, James, Cadzow Colliery, Hamilton, - - 1885
Cranston, David, Woodend Colliery, Armadale, - - 1880
Crichton, A. H., Hillside, Linlithgow, - - - 1880
Crockett, John D., Curran House, Dungannon, - - 1880
Crookston, Andrew, Wemyss Colliery, Dysart, Fife, - 1880

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Crookston, Thomas, Townhill, Dunfermline, - - 1879
Cunninghame, Archibald, Eglinton Iron Co., Dalry, - 1881
Cuthbert, Robert, Gauchalland Colliery, Galston, - - 1881

Danks, Henry, Green Colliery, Wishaw, - - - 1880
Dewar, Peter, Braidwood Colliery, Carluke, - - 1878
Dewar, Robert, Harthill Colliery, Whitburn, - - 1881
Dewar, Thomas, Glencleland Colliery, Wishaw, - - 1881
Drinnan, John, Trowell Moor Colliery, Nottingham, - 1880
Duncan, George, Leven Colliery, Leven, - - - 1881
Dunsire, Andrew, Cameron Colliery, Windygates, - 1883

Easton, Alexander, 13 South Bridge Street, Bathgate, - 1883

Falconer, Thomas, 40 Witch Road, Kilmarnock, - - 1880
Faulds, Alexander, Dalzell Colliery, Motherwell, - - 1878
Ferguson, David, Cadzow Colliery, Hamilton, - - 1878
Ferguson, Duncan, Lochore and Capeldrae Collieries, Lochgelly, - - - - - - 1880
Findlay, Hugh, Gartsherrie Colliery, Coatbridge, - - 1886
Forbes, Alexander, Allanton Colliery, Hamilton, - - 1885
Forgie, James T., Twechar, Kilsyth, - - - 1878
French, John, Millcroft Cottage, Rutherglen Road, Glasgow, - - - - - - 1879
Frew, William, Barncluith Colliery, Hamilton, - - 1887
Fulton, David, Dalquharran, Maybole, - - - 1881

Gardner, Thomas, jun., Auldton Collieries, Dalserf, - 1881

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Gavin, James, Udston Colliery, Hamilton, - - 1880
Gemmel, James, Govan Colliery, Glasgow (*Councillor*), - 1878
Gibson, William K., Ayr Colliery, Ayr, - - - 1886
Gilchrist, James, Earnock Colliery, Hamilton *(Councillor)*, 1878
Gillon, William, - - - - - - 1881
Gilmour, James, Duchray Colliery, Coylton, Ayr, - 1881
Goldie, James, Barncluith Colliery, Hamilton, - - 1887
Goodwin, George, Livingston Land, Langloan, Coatbridge, 1885
Gordon, Gavin C., Knightswood Colliery, Maryhill, - 1878
Grant, John, Bog and Home Farm Collieries, Larkhall, - 1878
Grant, Robert, Bardykes and Hallside Colliery, Newton, - 1881
Gray, David, Chapel Colliery, Newmains, - - 1885
Gray, John, Ashfield Buildings, Uphall, - - - 1885
Gray, William, Common Cottage, Auchinleck, - - 1880
Gray, William, Townlands Colliery, Hamilton, - - 1885
Green, William, Galston Colliery, Galston, - - 1883

Haddow, John, Arniston Colliery, Gorebridge, - - 1879
Hamilton, James, 97 North Frederick Street, Glasgow, - 1883
Hamilton, James, - - - - - - 1883
Hardie, James, Hopetoun, Winchburgh, - - - 1882
Hart, John, Clyde Iron Works, Tollcross, - - 1881
Hastie, James, Greenfield Colliery, Hamilton *(Councillor)*, 1879
Hastie, William, Gilmilnscroft, Auchinleck, - - 1881
Henderson, Andrew, Muiravonside Colliery, Bowhouse, Linlithgow, - - - - - 1880
Henderson, William, Levenseat, Fauldhouse, - - 1884
Herd, Peter, Dunnikeir Colliery, Kirkcaldy, - - 1880

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Herd, Samuel, Balgonie, Markinch, - - - 1885
Herd, Thomas, Dunnikeir Colliery, Kirkcaldy, - - 1880
Hill, James, Dalmellington, - - - - 1880
Hillhouse, William, Bonnyton Cottage, Kilmarnock, - 1883
Hogg, John, North Motherwell Colliery, Motherwell *(Councillor)*, - - - - - 1878
Hogg, William, Carnmoor Cottage, Forth, by Lanark, - 1881
Howat, John T., Maxwood Colliery, Galston, - - 1883
Howat, Robert M., Hopetoun Works, Winchburgh, - 1886
Howat, William, Dunsyston Colliery, Clarkston, Airdrie, - 1886
Howat, William, Southrigg Colliery, Armadale, - - 1886
Howie, James, - - - - - - 1883
Hunter, Adam, Bourtreehill Colliery, Dreghorn, - - 1885
Hunter, A., Alloa Colliery, Alloa, - - - - 1880
Hunter, Andrew, Orbiston Colliery, Bellshill, - - 1878
Husband, John, Kirkwood Colliery, Coatbridge, - - 1881

Ireland, Thomas, Largoward, St. Andrews, - - 1881

Jackson, Douglas, Ross Colliery, Hamilton, - - 1880
James, William, Niddrie Colliery, Portobello, - - 1883
Jamieson, Alexander, Balgonie Colliery, Markinch, - 1878
Jamieson, William, Byars Buildings, West Calder, - 1879
Johnstone, Hugh, Niddrie Collieries, Portobello, - - 1879

Kennedy, Alexander, Broxburn Oil Works, Broxburn, - 1882
Kerr, Archibald, Barncluith Colliery, Hamilton, - - 1881
Kerr, Archibald, Bankend Colliery, Lesmahagow, - - 1881

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Kerr, William, Barncluith Colliery, Hamilton, - - 1885
Kirkwood, Archibald, Dalzell Colliery, Motherwell, - 1878
Kirkwood, William, Shottstown, Penicuik, - - 1880
Knox, James, Allanton Colliery, Newmains, - - 1880

Laird, Andrew, 1 Corunna Street, Glasgow, - - 1883
Landor, Francis, Brownlee Colliery, Carluke, - - 1885
Legat, A. S., Loanhead Colliery, Edinburgh, - - 1879
Leggate, John, 191 Merry Street, Motherwell, - - 1881
Lennox, John, Cloncurry, Queensland, - - - 1885
Lindsay, Thomas J., Castlehill Iron Works, Carluke, - 1885
Lithgow, Thomas, Langbyres Colliery, Omoa, Motherwell, 1882
Livingstone, Archibald, Pentland Oil Works, Loanhead, - 1880
Love, John, Gartness Colliery, Airdrie *(Councillor)*, - 1878
Love, John, Portland Iron Works, Hurlford, - - 1882
Love, William J., Shotts Iron Coy., Shotts, - - 1881

M'Beth, Peter, Callander Coal Co., Falkirk, - - 1879
M'Cairn, Nicol, 7 Drum Terrace, Easter Road, Edinburgh, 1881
M'Culloch William, Linkieburn House, Muirkirk, - 1881
M'Donald, John, Greenhill Colliery, Holytown, - - 1880
M'Gown, John, Gilmerton Colliery, Liberton, - - 1883
M'Farlane, Walter, West-end Cottage, Chryston, - - 1882
M'Feddris, William, Elgin and Wellwood Collieries, Dunfermline, - - - - - - 1880
M'Gee, John, Tillicoultry Colliery, Tillicoultry, - - 1880
M'Kay, James, Roughrigg Colliery, Airdrie, - - 1880
M'Kenzie, Daniel, Blackhill Colliery, Bishopbriggs, - 1886

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M'Kenzie, John, Lambhill, Bishopbriggs, - - - 1886
M'Knight, John, Westwood Colliery, Bellside, Holytown, 1886
M'Neil, James, Glencleland House, Wishaw, - - 1878
M'Phail, James, Balbardie Colliery, Bathgate, - - 1884
M'Pherson, Gilbert, Holmes Colliery, Galston, - - 1881

Makepeace, Hugh R., Evenwood and Tees Hutton Collieries, Evenwood, Bishop Auckland, Co. Durham, 1881
Malcolm, James, Craigneuk Colliery, Motherwell, - - 1879
Martin, Robert, Pentland Oil Works, Loanhead, - - 1879
Martin, William, Douglas Park Colliery, Bellshill, - 1881
Mathie, James, Cornsilloch Colliery, Larkhall, - - 1879
Maxwell, James, Limerigg Colliery, Slamannan, - - 1882
Middleton, George, Westburn Colliery, Newton, - - 1886
Millar, William, Townlands Colliery, Hamilton, - - 1883
Milligan, Peter, Cleland, - - - - - 1884
Moffat, James, Allanton Colliery, Hamilton, - - 1885
Moffat, William, Heatheryknowe Colliery, Bargeddie, - 1885
Moodie, Thomas, Devon Colliery, Alloa, - - - 1881
Morrison, John, Appletree Cottage, Larkhall, - - 1884
Morton, John, Rankinston Works, Ayr, - - - 1880
Morton, R. M., Ansonhill House, Crossgates, Fife, - 1879
Morton, William S., Niddrie Collieries, Portobello, - 1884
Mowat, David M., Summerlee Iron Works, Coatbridge, - 1886
Muir, W. W., Coltness Colliery, Newmains, - - 1878
Munro, James, Quarter Iron Works, Hamilton, - - 1879
Munro, Neil, Twechar, Kilsyth, - - - - 1886
Murray, John, Greengairs, Airdrie, - - - 1879

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Naismith, Samuel, Quarryhall Crescent, Hamilton (*Librarian*),- - - - - - 1884
Nasmyth, A., Donibristle Colliery, Crossgates, Fife, - 1880
Neilson, Benjamin, Prestongrange Coal Coy., Prestonpans, 1880
Ness, Henry, Benarty Colliery, Blairadam, Kelty,- - 1880
Nevill, Thomas W., 95 Bath Street, Glasgow, - - 1886
Nimmo, Thomas, Fauldhouse Colliery, Fauldhouse, - 1879
Nisbet, Andrew, Kinneil Works, Bo'ness, - - - 1884
Nivison, John, Dykehead Colliery, Larkhall, - - 1886

Orr, Thomas, Shotts Iron Coy.'s Polkemmet Works, Bathgate, - - - - - - 1881

Park, James, Wellhouse, Rutherglen, - - - 1883
Park, Joseph, Allanshaw Colliery, Hamilton, - - 1878
Paterson, Hugh, Braidhurst Colliery, Motherwell, - 1881
Paterson, Thomas, 95 Bath Street, Glasgow, - - 1883
Paul, James, Law Colliery, Carluke, - - - 1881
Peddie, John, - - - - - - 1886
Penman James, Kinneil Works, Bo'ness, - - - 1883
Pettigrew, Robert, 66 Flowerhill Street, Airdrie, - - 1881
Phillips, John, Birkenshaw Colliery, Larkhall, - - 1880
Pitcairn, Gilbert, Eddlewood Colliery, Hamilton, - - 1880
Pitcairn, James S., Hollandbush, Hamilton, - - 1885
Pollock, William, 4 Bothwell Road, Hamilton, - - 1884
Prentice, James, Stanrigg Collieries, Airdrie (*Councillor*), - 1881
Prentice, Joseph, Addiewell Colliery, West Calder, - 1880
Prentice, Thomas, Addiewell Works, West Calder, - 1879

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Rattray, Thomas, Raith Colliery, Lochgelly, - - 1884
Ritchie, James, Tannochside Colliery, Uddingston, - 1885
Robertson, Alex., Benwhat, Dalmellington, - - 1880
Robertson, Archd., Bathville Colliery, Armadale, - - 1880
Robertson, David, Dalquharran Colliery, Maybole, - 1881
Robertson, James A., 54 Blacket Place, Edinburgh, - 1885
Robertson, John, Lanemark Colliery, New Cumnock, - 1880
Robson, Robert, Sydney Mines, Cape Breton, Nova Scotia, 1882
Rodger, Alexander L., Tharsis Mines, Huelva, Spain, - 1884
Rome, J. E., Shotts Iron Works, Shotts, - - - 1886
Ronaldson, James H., Trabboch Colliery, Coylton, Ayr, - 1879
Rorison, John, Springhill Colliery, Kilmarnock, - - 1883
Ross, Alexander, Glenhead, Camp, Motherwell, - - 1880
Ross, Michael, Drumsmudden Colliery, Ochiltree, - - 1878
Rowan, Donald, Broomhouse, Colliery, Broomhouse, - 1884
Rowan, Henry, Gartgill Cottage, Bothwell, - - 1881
Russell, Alexander, Dalmeny, Edinburgh, - - 1883
Russell, Charles, Harthill Colliery, Whitburn, - - 1886
Russell, W. S., Binnend Cottage, Burntisland, - - 1880

Scobie, William, Gilbertfield Colliery, Cambuslang, - 1881
Scott, John, Calder Iron Works, Coatbridge, - - 1879
Seggie, James, Merryton Colliery, Hamilton, - - 1885
Semple, Henry, - - - - - - 1884
Semple, William, jun., Crosby and Gilcruix Collieries, Maryport, Cumberland, - - - - 1880
Semple, William, sen., Goatfoot Colliery, Galston, - 1881
Sharp, A., Sheardale Colliery, Tillicoultry, - - 1880

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Sharpe, George, Wilsontown Colliery, Lanark, - - 1881
Shore, Wm. M., Kaitangata, Dunedin, New Zealand, - 1886
Smith, David, Dalmellington Iron Works, Ayr, - - 1885
Smith, William, Thornton Colliery, Lochfitty, Dunfermline, 1886
Simpson, Dundas, Ellismuir Colliery, Baillieston, - - 1879
Simpson, James, Shields Colliery, Motherwell, - - 1881
Smith, Hamilton, Cadzow Colliery, Hamilton, - - 1878
Smith, James, Twechar, Kilsyth, - - - - 1881
Smith, John, Cannock Lodge Colliery, Bloxwich, Staffordshire, - - - - - - 1878
Smith, John, Rosehall Colliery, Coatbridge, - - 1880
Sneddon, James B., Oakbank Colliery, Mid-Calder, - 1886
Somerville, William, Bredisholm Colliery, Uddingston, - 1880
Stewart, H., Tranent Colliery, Tranent, - - - 1881
Stewart, Robert, Legbrannock Collieries, Holytown, - 1883
Stirling, John, Bonnybridge, - - - - 1880

Telfer, Henry, Overtown Colliery, Wishaw (*Councillor*), - 1878
Thom, Archibald, Baird's Mines, Lamplugh, Cockermouth, 1881
Thomson, A. M'D., Rawyards Colliery, Airdrie, - - 1880
Thomson, George, Launcherhead, Lochgelly, - - 1884
Thomson, James, Ross Street, Dunfermline, - - 1883
Thomson, John, Stevenston Colliery, Newarthill, Motherwell, - - - - - - 1880
Thomson, Richard, Easter Shirva, Kirkintilloch, - - 1878
Thomson, Thomas, Balquhatston Colliery, Slamannan, - 1879
Turner, William, Chapel Colliery, Newmains, - - 1881
Twaddle, William, Ferniegair, Hamilton, - - - 1878
Waddell, Alexander W., Kinneil Iron Works, Bo'ness, - 1883

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Waddell, Robert, Blackston Works, Paisley, - - 1880
Waldie, A. B., 25 Douglas Crescent, Edinburgh, - - 1885
Walker, David, Garscadden Works, Bearsden, - - 1880
Walker, David, jun., Bathville Collieries, Armadale, - 1884
Walker, George B., Tankersley Grange, Barnsley, - 1887
Walker, Robert, Bog Colliery, Larkhall, - - - 1881
Walker, William, Rigside Colliery, Douglas, - - 1880
Wardlaw, John, Garriongill Colliery, Wishaw, - - 1878
Wardlaw, Robert, Hermand Oil Works, West Calder, - 1883
Webster, David, Burdiehouse Lime Works, Edinburgh, - 1880
Weir, William, 3 Low Patrick Street, Hamilton, - - 1884
White, James, Crosshill Cottage, Dreghorn, - - 1885
Wilkie, William, South Arnloss Colliery, Slamannan, - 1885
Williams, John, 16 Blanche Street, Dowlais, South Wales, 1884
Williamson, James, Dunbeth Terrace, Coatbridge, - 1880
Williamson, William, Beckford Street, Hamilton, - - 1886
Wilson, James, Barncluith Colliery, Hamilton, - - 1880
Wilson, Robert, Longrigg Colliery, Slamannan, - - 1880
Wilson, Robert, Eastgrange Cottage, Dunfermline, - 1880
Wilson, William, Auchinraith Colliery, High Blantyre, - 1879
*Wilson, William, Dykehead Colliery, Larkhall, - - 1880
Wilson, William, Eastend, Broxburn, - - - 1881
Winning, Andrew, Loganlea Coal Co., West Calder, - 1882
Wood, Thomas, Dalmeny, - - - - - 1887
Wylie, James, Townhill Colliery, Dunfermline, - - 1880
Wyper, James, Mauldslie Colliery, Carluke, - - 1880

Yates, Andrew, Bellfield Colliery, Hurlford, - - 1881

*Deceased.

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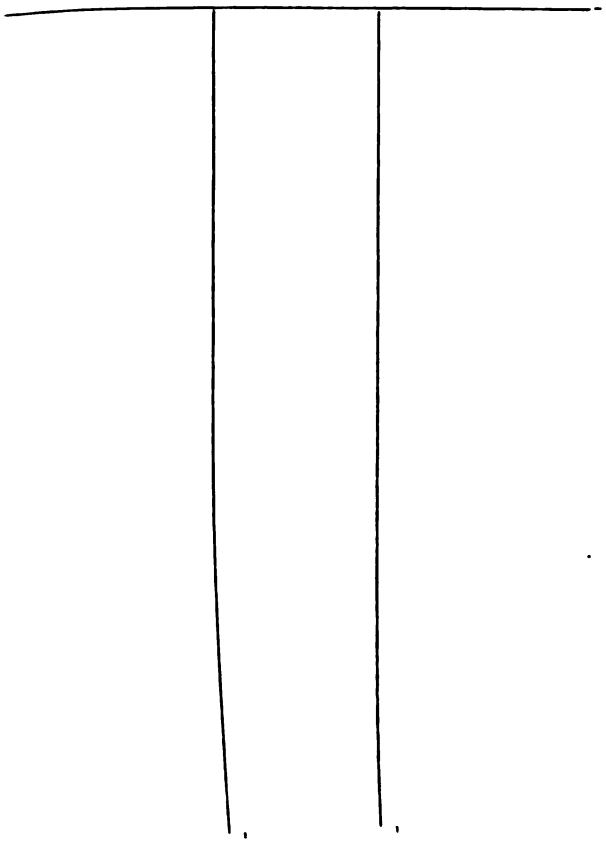

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